JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA

FOR THE

PROMOTION OF THE MECHANIC ARTS.

JANUARY, 1849.

CIVIL ENGINEERING.

Wrought Iron Bowstring Girders for Bridges.

The following diagram represents a wrought iron rib, or girder, now being employed in the construction of bridges, of 120 feet and 130 feet span, at Messrs. Fox, Henderson & Co.'s establishment, the London Works, near Birmingham, under the superintendence of Mr. Jos. Locke, C. E., M. P. On the 6th instant, one of them was publicly tested at the works, in the presence of a number of scientific gentlemen and engineers.

The bridge rib had been erected, ready for proof, in an open space in front of the London Works, and presented a clear span of 120 feet between the bearings. It is constructed entirely of wrought iron, and consists of an arch of boiler plates and angle iron, tied across at the ends by horizontal bars, and the tie bars are connected with the arch by vertical standards, and by a double system of diagonals, which have the effect of distributing over the whole curve of the arch, the action of weights placed on, or passing over, any point of the bridge. The proof was applied by loading

the bridge rib with 240 tons of rails, bars, &c.; and it produced the following satisfactory results, as the weight was applied:—

Weight in tons of rails, &c. placed on the cross girders.	Extreme amount of deflection produced at centre of arch.
$34\frac{1}{4}$ tons,	$0\frac{1}{16}$ inch.
$68\frac{1}{2}$ "	$0\frac{5}{8}$ "
$102\frac{3}{4}$ "	$1\frac{5}{16}$ "
137 "	$2\frac{1}{8}$ "
$171\frac{1}{4}$ "	$2\frac{3}{4}$ "
$205\frac{1}{4}$ "	$3\frac{5}{16}$ "
240 "	$3\frac{11}{16}$ "

The proof weight was fixed at 240 tons, as being double the greatest load which the bridge can, by any possibility, be ever required to bear. A heavy goods train weighs less than half a ton per foot lineal; a train, consisting entirely of locomotive engines, (which would be the heaviest of all possible trains,) would only weigh one ton per foot lineal, and, consequently, would place a load of not more than 120 tons on a bridge of 120 feet span. The new bowstring bridge has, therefore, been proved to twice the weight which ever can be placed upon it, and to four times the weight which it is ever likely to have to bear. It is scarcely necessary to add, that the trial gave great satisfaction to all parties. These ribs are adapted for large spans, in cases where either headway is of importance, or where sufficient abutment cannot be obtained, without very heavy expense. Bridges constructed of these ribs, may be employed with perfect safety for very large spans, in precisely the same manner as ordinary girders are used for small ones. The strength of the bridge depends upon the rib, or arch, and on the tie bars, by which the extremities are held together. The vertical standards are introduced, partly to suspend the load from the arch, and partly to obtain longitudinal and transverse firmness; they also support the tie-bars. The diagonals are employed for the purpose of preventing undue deflection in the rib, when the bridge is unequally loaded. The rib itself is constructed of boiler plates and angle iron riveted up in the form of a square hollow trunk; it is strongly tied together, so that the full section of the plates and angle iron may be depended upon, to resist the crushing strain. In order to give this trunk additional lateral stiffness, the side plates, which form the top, are made to overhang, and are strengthened on the edges by angle iron, &c. The tie-bars measure about 8 inches by 1 inch each, and are introduced in sufficient numbers to take the whole strain. The ribs are supported at each end, on cast iron shoes, fixed at one end to the piers, and mounted at the other on sliding frames and rollers. This arrangement provides not only for expansion and contraction, but also for motion under a very heavy load. The action of these parts, under proof, has been found to be perfect. Cross girders, constructed entirely of wrought iron, are suspended between the ribs.

Besides the above experiments, the two ribs for a bridge, 130 feet span, have been proved with a weight of 260 tons—*i. e.*, 2 tons per foot lineal —each, put on in dead weight, by suspending cast iron cross girders underneath the points where the wrought iron girders are intended to be

attached, and by placing thereon 260 tons of rails, pigs, bars, &c. In proving, the load was first put on two points at one end, then on the next two points, and so on, in order to produce, as nearly as possible, the same effect as the passage of a heavily loaded train. In the case of one rib, the load was allowed to remain for several days, and then removed. After the lapse of a few days, the same load was replaced, and again allowed to remain some days. The results were very satisfactory.

During the process of proving, observations were taken with a dumpy level, placed at a distance; and the sinking of the bearing plates in the ground was observed and noted. The bridges now being constructed, are intended to carry a double line of rails; and the test applied is, therefore, equal to two tons to each foot lineal of single line of rail. This test was fixed upon, in the belief that the greatest possible load which can, in working, be placed upon each line of rails, is about one ton per foot lineal; and that, to provide for the additional strain caused by the rapid motion, &c., of the practical load of trains passing, the proof-weight ought to be fixed at double the greatest possible load. In very large spans, (say 400 feet and upwards,) it would be necessary, on many accounts, to use four ribs instead of two, and to brace all the four ribs together overhead, so as to obtain additional transverse stiffness.—*Mining Journal.*

Lond. Mec. Mag., Sept. 1848.

The Don Bridge on the Northern Railway.

The pile-driving at the Don bridge is completed, and the masonry work for the abutments commenced. We learn, from the Doncaster Chronicle, that the bridge will be constructed of wrought iron, on the principle of Fairbairn's patent hollow bridge, and will consist of two hollow iron girders, which will span the stream, transverse girders for the rails to rest upon, and iron plate sides. The bridge will be 5 feet 6 inches high in the middle, 4 feet 8 inches at the ends, the side plates being only $\frac{5}{16}$ths of an inch thick; the plates at the bottom of the bridge are $\frac{9}{16}$ths of an inch thick. All these will be firmly riveted together, to form a rectangular beam. The bridge will be remarkable, chiefly, for its combination of lightness with strength and durability. The principle of construction is the same as that adopted at Conway, and which is now being very generally adopted for railway bridges. The span of the bridge will be 70 feet.

Lond. Builder, Sept. 1848.

Atmospheric System of South Devon.

The atmospheric system on the South Devon line has been abandoned, by the advice of Mr. Brunel, who had adopted it, it was alleged, at an expense to the Company of £343,535. The Directors, at their late meeting, avoided all discussion of this sore point from "legal considerations." They have resolved, however, to allow the patentees and Mr. Samuda to experiment with the materials, "until the same shall be made efficient."

Ibid.

Extracts from the Annual Report of B. H. LATROBE, ESQ., *Chief Engineer of the Baltimore and Ohio Railroad Co., submitted by the President and Directors, at a meeting of the Stockholders, October* 9, 1848.

Maintenance of Road.—Main Stem.

1. *The Road Bed.*—There is but little remark to be made under this head, excepting what will be said hereafter upon the *improvements* east of the Monocacy river. The road surface, culverts, and drains, are generally in good condition, and have suffered little from water during the past year.

2. *The Railway Tracks.*—At the beginning of the year just expired, (Oct. 1, 1847,) there were the following lengths of track of different kinds:

Plate rail, east of Harper's Ferry, laid in 1830–31,	51 miles.
H rail, east of Harper's Ferry, laid in 1838,	19 "
∩ rail, west of Harper's Ferry, laid in 1841–42,	97 "
∩ rail, east of Harper's Ferry, laid in 1846–7–8,	41 "
Making a total of	208 miles.

Since the first of October, 1847, there have been laid, east of Harper's Ferry, 17 miles of ∩ rail, in place of an equal length of plate rail; so that the account stands thus at this date, October 1st, 1848:

Plate rail, east of Harper's Ferry, laid in 1830–31,	34 miles.
H rail, east of Harper's Ferry, laid in 1838,	19 "
∩ rail, west of Harper's Ferry, laid in 1841–42,	97 "
∩ rail, east of Harper's Ferry, laid in 1846–7–8,	58 "

Of the 61 miles of ∩ rail directed to be laid east of Harper's Ferry, there are, therefore, but 3 miles still to lay, the materials for which are provided, and will be put down as soon as the new gradation of the parts of the road for which they are intended, is ready to receive them.

Of the 34 miles of plate rail remaining upon the road, 2 miles is in the city of Baltimore, between the City Block and Mount Clare depôt—13 miles in the second track between Mount Clare and Ellicott's Mills—13 miles in the second track between Parr's Bridge and the Monocacy—3 miles in the Frederick branch, and the 3 miles ready to be relaid as above. The lighter half of the business of the road passes over the second and third of these sections, which has made it the more practicable to keep them up. The section in the city of Baltimore has been relaid during the year, with a thicker bar, and upon timber instead of stone, as will be noticed under the head of "Improvements." The Frederick branch being short, and the weight and speed of the trains moderate, may be maintained well enough with the plate rail. Nevertheless, the expediency of reconstructing the whole of this track, with a heavy rail, so soon as the means of the company will allow, cannot be questioned.

The cost of current repairs of the track thus composed, has, during the year just ended, been as exhibited in the following table. The number of miles of each kind of track is the *average* kept up through the year, the ∩ rail east of Harper's Ferry increasing as the plate rail decreases in extent. In the column of "cost per mile," the *upper* figures opposite each description of rail, include the ditching, &c., of the road bed, not dependent on the kind of track, and the lower figures shew the cost of maintaining the track alone.

Apportionment of the Cost of Repairs of Railway among the different kinds of Track upon the Baltimore and Ohio Railroad, during the year ending September 30th, 1848.

Description of Track.	No. of Miles.	Cost of Labor.	Cost of Lumber.	Cost of Iron Bars.	Cost of Castings.	Cost of Bolts and Spikes.	Miscellaneous.	Deduction for old Materials sold and Stock on hand.	Average Cost per mile.	Total Cost.
Plate Rail, . .	44	$18,420·79	$10,471·64	$4,136·54	$1,597·08	$3,447·19	$6,560·11	$4,192·57	{ 920 / 821 }	$40,440·78
H Rail, . . .	19	9,109·85	5,437·66		1,312·15	1,202·97	1,752·13	3,242·13	{ 820 / 756 }	15,572·63
∩ Rail east of Harper's Ferry, .	48	16,138·28	1,200·00		651·36	392·60	2,390·37	4,664·22	{ 336 / 269 }	16,108·39
∩ Rail west of Harper's Ferry, .	97	45,542·28	49,462·42		4,782·58	5,036·41	2,865·75	12,446·19	{ 982 / 932 }	95,243·25
Totals, . .	208	$89,211·20	$66,571·72	$4,136·54	$8,343·17	$10,079·17	$13,568·36	$24,545·11	{ 805 / 744 }	$167,365·05

The above amount embraces the expense of maintaining no less than 21⅜ miles of siding and depôt tracks.

The above aggregate of $167,365·05 agrees with the statement of the Treasurer; but there must be deducted the sum of $3,066·38 for increased stock of materials on hand, which leaves $164,298·67 as the true cost of maintenance.

The preceding apportionment is sufficiently exact to shew the relative cost of maintaining each kind of track during the year—and from it may be inferred, that, if the plate rail had been entirely superseded by the ∩ rail, the saving in current repairs would have been $24,288.

During the preceding year, ending September 30th, 1847, the total cost of maintenance was $131,926·30. The expense, then, of the present year, exceeds that of the last by $35,438·75. This is chiefly due to the extensive renewal of the wood work of the H rail track, and of the ∩ rail track west of Harper's Ferry, which last, as noticed under this head in my last annual report, (see page 36,) is now in the seventh year since it was laid, and is passing through the period of entire renovation, which will be completed by the end of the current year terminating with 1849. The repairs of the coming year will, however, be very considerably lighter than those of the year just closed.

Some remarks upon the character and wear of railway tracks may be appropriate in this place,—as an impression appears latterly to have prevailed, that the description of track laid west of Harper's Ferry in 1841–42, and east of that point, in the reconstruction of the road in 1846–47–48, is more costly to maintain, as well as to construct, and otherwise imperfect in its structure. This plan of track was adopted by the board for the road west of Harper's Ferry, after a careful consideration of the whole subject by their late chief engineer, J. Knight, Esq., aided by the undersigned. The H rail track, of which the company had 19 miles laid in 1838, had, in their judgment, shewn serious defects in its structure, similar to those apparent in tracks of the same kind on other roads, and which they believed would be, in a great measure, obviated by the use of a continuous bearing of timber under a rail of the same weight, but of a form better calculated to *wear* well. They, therefore, chose the ∩ or bridge rail, in connexion with a string timber for its support. The subsill used upon most other roads at that time was retained, and, in consequence of the use of this additional longitudinal timber, the number and size of the cross-ties were so much diminished, as to give very little more perishable matter in the track, than in those laid upon cross-ties only. The only changes, therefore, in the plan of 1838, were in the form of the rail, and the introduction of a light wooden bearer under it, which, breaking joints with it, gave a great increase of strength at the ends of the bars, and supported the rail, and held it much better in place *lengthwise*, than it was practicable to do with the cross-ties alone. This part of the plan was not new, but had been in successful use on the Washington branch road for several years. It was also a feature in some of the principal lines in England, and was advocated and preferred by some of the most distinguished engineers of that country, and was growing into favor in America also—the first section of the New York and Erie Railroad having been laid in that way. It is true that, in New England and other parts of the United States, the continuous bearing under the rail was not then used, but the cross-tie alone, or in connexion with the sub-sill, was preferred. More recently, however, the continuous bearing seems to have recommended itself to New England engineers; as the great line of railway from Portland to Montreal is to be laid on that plan, and also the road from Portland to Augusta,—and, what is worthy of remark, the Eastern Railroad, from Boston through Salem, &c.,

is being re-constructed with a continuous bearing, having been originally laid upon cross-ties only.

A similar example, nearer home, is also to be seen in the Philadelphia and Trenton Railroad, and the Camden and Amboy Railroad, where the continuous bearing appears to be superseding the cross-tie. In the State of Georgia, it may be added, that the continuous bearing is used, and considered preferable. These observations are offered to show that the engineers of the company, at the time the track of 1841 was planned, were supported by the authority and practice of eminent engineers elsewhere, and that the experience acquired since then, has led others to the same conclusions.

In comparing the cost of maintaining this track, with that of others of a different form, it is difficult to select any road of sufficiently similar character in all respects, to make the comparison satisfactory. The Western Railroad, of Massachusetts, perhaps more nearly resembles the Baltimore and Ohio Railroad, than any other existing line. Upon the Western Railroad, in the year ending December 1st, 1847, the sixth year after its opening for its whole length, the cost of repairs per mile of single track was $1180; while upon the Baltimore and Ohio Railroad west of Harper's Ferry, the cost per mile, for the year ending this day, being also the sixth year after its opening, is $982. So that the Western road appears to have cost $198 per mile more than the Baltimore and Ohio road. The number of trips made by trains over the whole length of each road, and the operation of that cause of wear and tear, differed but little. The iron rail upon the Baltimore and Ohio Railroad weighs but 51 lbs. per yard—that on the Western Railroad from 56½ to 70 lbs. per yard; yet the cost, in 1847, of renewing iron on the Western road was $29,119, or at the rate of $213 per mile, while upon the part of the Baltimore and Ohio Railroad in question, it was *nothing* during the year just expired—and promises to be nothing for some years to come. The cost of renewing iron on the Western road was, in the year 1846, $24,522, so that, within the two years prior to the present, there had been $53,641 spent in renewals of iron. The amount expended before that period, is not shown in the published statements of the company, but must have been something, and the renewals this year will probably be considerable, as, when iron begins to go, its destruction advances with accelerated speed. That this difference in the wear of the iron has something to do with the general structure of the track, as well as the form of the rail, cannot be doubted. The reason simply is, that the lighter rail of the Baltimore road is better *supported*, especially at the *joints*, where the chief destruction takes place, and the result of this comparison clearly shows that increased weight in the rail is not, of itself, sufficient to secure increased durability; but that the form of the rail, and the frame of the track, have an important influence upon the wear of the iron bar.

It may be observed, that the H rail track on the Baltimore and Ohio Railroad, laid on cross-ties, appears, although four years longer in use, to have cost this year less, by $176 per mile, than the ∩ rail west of Harper's Ferry, with the string piece. But it is to be said, on the other hand, that, although the H rail track is the older, yet it has not carried much more than the other; as the most of it is on a part of the road where the trade is

divided between two tracks. Moreover, the iron of the H rail had, when as old as the ∩ rail is now, sustained much injurious wear, and although not many bars have been yet removed entirely from the track, yet a great number are so far gone, as to be nearly unfit for further service. The next two or three years will, it is believed, show a decided difference in the wear of the tracks in favor of the ∩ rail, with its continuous bearing.

It is objected to the track of continuous bearing, that it is less readily adjusted when out of order, than the track upon cross-ties alone. This is in a measure true; but, on the other hand, it is less subject to derangement, so that, on the whole, it may require no more labor to keep it in order. It is said to be more subject to give way sidewise, by the yielding of the timber. There may be more weight in this suggestion; but the difference of risk is, after all, inconsiderable, so long as the timber remains sound. Accidents from this cause have happened, but they have been always, (except in case of decay in the timber,) where the curvatures were extreme, and in these cases they have occurred upon the one kind of track as well as the other. After all, however, that can be said on both sides, it must be conceded that in the simplicity of the cross-tie track there is much that is attractive; and were means found to obviate the evils arising from the greater imperfection of the joints of the bars, on that kind of track, it would, in the main, be preferable. This, in the opinion of the undersigned, can only be effected by an entire change in the form of the iron rail, by which the advantages of the combination which it possesses with the continuous timber bearing may be realized in the rail itself. Apart from this consideration, however, I am of opinion that it would be unwise to adhere to either plan *uniformly*, but that the one or the other should be chosen, as it may be best suited to the local peculiarities of the line; as it is the duty of the engineer always to adapt his modes of construction to the circumstances of his work. Accordingly I did not hesitate, in the report upon the route west of Cumberland, which I had the honor to submit to the board on the 8th of April last, to recommend that the string timber should be rejected, and the cross-tie alone used, (except on fresh embankments, where a sub-sill should temporarily be laid,) in connexion with a heavier rail than would be needed with the continuous bearing, and a more carefully planned and perfect fastening than any of those heretofore used, and whose inefficiency has been so fully demonstrated upon the best railways in the country.

These remarks might be greatly extended, in a further discussion of the subject; but the space already devoted to them, is as much as can be spared here, and I would only offer the further remark, that, in comparing the wear of tracks on different roads, we should be careful to consider the relative *trade* of each, upon which the wear and tear chiefly depend; and when we see a road of moderate or light traffic, apparently in better order than one of heavy trade, with a different kind of track, we should not hastily conclude that the difference in the condition of the road, is attributable altogether to superiority in the structure of the one which happens to be in the best condition.

Performance in Miles Run.—Main Stem.

18 first class engines, with freight trains, have run	249,621	miles.
4 second class engines, with freight trains,	40,119	"
13 third class engines, with freight trains,	159,319	"
The same engines, with passenger trains,	133,808	"
17 fourth class engines, with freight trains,	249,846	"
The same engines, with passenger trains,	81,980	"
52 engines of all classes, with passengers,	215,788	"
do. with freight,	698,905	"
Making a total with passengers and freight of	914,693	"

Washington Branch.

2 third class engines, with passenger trains, have run	54,220	miles.
3 fourth class engines, with passenger trains,	34,350	"
The same engines, with freight trains,	36,216	"
5 engines of both classes, with passengers, have run	88,570	"
do. with freight, have run	36,216	"
Making a total with passengers and freight of	124,786	"
57 engines of all classes, upon both roads, have run with passengers,	304,358	miles.
with freight,	735,121	"
Making a total with passengers and freight of	1,039,479	"
The average of the 18 first class engines, with freight alone, has been each	13,868	miles.
The average of the 4 second class engines, with freight alone, has been each	10,030	"
The average of the 15 third class engines, with freight and passengers, has been each	23,156	"
The average of the 20 fourth class engines, with freight and passengers, has been each	20,120	"

Five engines of the first, two of the second class, and one of the third, have been less than a year upon the road, having been placed upon it at various times since October 1st, 1847. Hence the average performance of those classes has been less in proportion to that of the fourth class, the number of which last has not been increased during the year, but, on the contrary, diminished by the transfer of two of its number to the third class, in re-constructing them so as to add to their weight and power.

So many circumstances influence the amount of work done by each class, that it would be unsafe to infer, from the comparison of miles run by each, that one class was more efficient than another. In their several departments of duty they are all useful—although it is, in general, true, that freight is most economically transported by engines of the first class, and passengers by those of the third class, upon a road of this character. An-

other general deduction from the relative duty in miles run, is that the passenger engines, with their lighter loads, and higher speed, and more regular routine of duty, lose less time, unemployed and under repair, than freight engines.

Performance in tons hauled one mile.

Of the 57 engines upon the road, (main stem and branch,) 49 are engaged regularly in the transportation of freight, (46 main stem and 3 Washington branch,) and 8, (6 main stem and 2 Washington branch,) in that of passengers. The average number of tons, (excluding the weight of the cars,) hauled 1 mile by the 49 freight engines of all classes, will have been 631,130 for each, and, expressing the number of those engines by that of their equivalent in the 4th or lightest class, we should have 93½ engines of this class, (90½ on the main stem, and 3 on the Washington branch,) and each of them would have drawn an average, on both roads, of 341,662 tons 1 mile. This tonnage includes materials and fuel distributed along the line for the company's use. Excluding that, and considering only the freight which has earned revenue, the performance will have been 301,898 tons hauled one mile by the power of each 4th class engine. This power is equivalent to an average traction (or adhesion) of about 1 ton; so that the relation between the effective weight of the engine, and its year's duty, is thus readily seen. If all the engines now on the road had done a *full* year's duty, the number of tons hauled 1 mile, of freight earning revenue, would have increased 13 per cent., or to 341,472 tons.

Comparing these statements with those of the preceding year, we find that the average duty of the engines has decreased $10\frac{7}{10}$ per cent. This is chiefly the result of the introduction upon the road of the additional power, by which the engines have been relieved of a portion of their duty, —a result which will be productive of real economy in their working.

Cost of Repairs of Locomotives.—Main Stem.

The sum exhibiting the cost of the materials and labor put into the engines and tenders, in maintaining their current repairs, and rebuilding them with improvements, when that was necessary or advisable, is $57,901·76: to which we add the cost of providing duplicate parts, for the engines, for future use, and kept in store for that purpose, $1242·37—which two amounts make an aggregate of $59,144·13. The actual current outlay during the year, in maintaining the engines, is the first of the above amounts only. It is less than the corresponding amount for the previous year, by $13,118·47. The average number of engines at work in 1847 was equivalent to 74 of the 4th class; and in 1848, to 84 of the same class. The increase in the number of engines has been, consequently, 13½ per cent. The duty in tons and passengers carried one mile is also greater by 8 per cent. The decrease in the cost of repairs is, on the other hand, 18 per cent. The value of the "improvements" to the engines, made during the past year, was about $9300, including the cost of converting two of the 4th class 6-wheel engines, into 8-wheeled engines of the 3d class. The cost of these improvements is embraced in that of repairs already stated. This remarkable reduction in the expense of maintenance, is due chiefly to the improved condition of the old engines, and the introduction of so

considerable a proportion of new ones,—to the amended state of the road, and other causes, which will promote a permanent economy in the department of machinery.

The cost of repairs per mile run, and per ton per mile drawn, has been nearly as follows for the several classes:

	Cents.			Cents.			
1st class,	9·93	per mile run,	and	0·147	per ton per mile drawn.		
2d class,	8·02	"	"	0·178	"	"	"
3d class,	5·50	"	"	0·265	"	"	"
4th class,	4·16	"	"	0·233	"	"	"
General average,	6·33	"	"	0·188	"	"	"

In this exhibit there is a uniform *decrease* in the cost per mile, from the 1st or heaviest, to the 4th or lightest class,—while there is a nearly similar uniformity in the *increase* of cost per ton per mile—showing clearly the superior economy in this item, of the heavy engine for freight purposes.

Washington Branch.

The cost of current repairs of locomotives on this road, for the year, is $3076.88; to which add, for duplicate parts provided, as before, $273·14; the two sums amounting to an aggregate of $3350·02. The first of these amounts, representing the actual cost of maintenance during the year, is $7801·96 less than that of the previous year, being indeed less than one-third of the latter. This great reduction is due to the greatly improved condition of the engines, and to the large increase of duty performed by them—being 25 per cent. in miles run, and 22½ in tons drawn.

The result per mile run, and per ton per mile drawn, is as follows:

	Cents.			Cents.			
3d class,	2·90	per mile run,	and	0·955	per ton per mile drawn		
4th class,	2·14	"	"	0·105	"	"	"
General average,	2·47	"	"	0·192	"	"	"

The third class engines upon this road have run entirely with passengers, which are here expressed by their equivalent at 12 to the ton. The cost per ton is shewn for the sake of conformity, and to show how much more costly, by weight, the conveyance of passengers is than that of tonnage.

The cost per mile, and per ton per mile, of the 4th class engines, is very small, as they have been run chiefly with freight; and they have been, in consequence of the work done upon them last year, in remarkably good condition.

Average upon both roads.—This for all classes, for the year, has been 5·89 cents per mile run, and 0·189 of a cent per ton per mile drawn. The corresponding result for the previous year was 10·14 cents per mile, and 0·3097 of a cent per ton per mile. The increase of miles run in the year just ended was 14⅓ per cent., and the cost per mile but little more than one-half of that of the previous year, while the cost of the real duty performed

was not more than two-thirds of that of the same year. The comparison is evidence of improved economy in the working of the engines, and is due, in part, to the improved condition of the engines already on the road, and of the road itself, and in no small degree to the relief afforded to the working of the machines, by the enlargement of the stock which has taken place during the year. This extension has operated well in several ways. When the engines have needed minor repairs, they have been taken at once to the shop, instead of being run until they would run no longer. The necessity of working upon them at night has been obviated, and this most imperfect and costly kind of work avoided. The engine-man has also had more time to clean and keep his engine in order. The general condition of the machines being much improved, their power has been increased. Fewer irregularities in the running of the trains have taken place, and where spare engines were wanted to replace disabled ones, they were at hand. It requires, indeed, no argument to shew that, in numerous particulars, economy in the operations of the road must have been promoted. During the year ending Oct. 12, 1847, there was 90 per cent. of the motive power constantly on the road. In the year just closed, the proportion was reduced to 82½ per cent. Upon the Reading Railroad, 80 per cent. of the power is usually on the road. On the Boston and Worcester Railroad 75 per cent. has been kept in motion, by dint of great exertions; on the Boston and Lowell Railroad about the same; on the Georgia Railroad from 62 to 75 per cent. I am of the opinion, indeed, that there should be a spare engine to every two in constant use, or that only 67 per cent. of the whole power should be kept in motion. This ratio has been the basis of all the calculations of the cost of motive power which have emanated from this department. It is the proportion observed in the running of our passenger engines, which wear so well, and which, after running two consecutive days, lie by upon the third for repairs. Want of capital may make it necessary to be content with a smaller investment in machinery than the adherence to this proportion would require. If so, it is a necessity, a submission to which may be unavoidable, but which will be felt in the increased expense of working the road.

Summary of Cost of Maintenance of Machinery.

The whole expense of maintaining the locomotives, passenger, and burden cars, during the year ending September 30th, 1848, has been upon the

Main Stem, under the several heads as above stated,	$151,143·31
Which is $4566·21 greater than the preceding year.	
Washington Branch, - - - - -	16,256·47
Which is $16,683·12 less than the preceding year.	
Total for both roads, - -	$167,399.78

Revenue, Expenses, and Trade.—Main Stem.

1. *Revenue.*—The receipts from their several sources are as follows, for the year ending September 30th, 1848, by the side of those of the previous year:

SOURCE OF REVENUE.	1848.	1847.	Increase. * Decrease. †
Passengers in Main Stem trains,	393,926·33	361,546·24	* 32,380·09
Passengers in Washington Branch trains carried over 8 miles of Main Stem,	51,328·01	42,266·20	* 9,061·81
Total for passengers carried,	$445,254·34	$403,812·44	* $41,441·90
Tonnage in Main Stem trains,	700,065·75	628,523·51	* 71,542·24
Tonnage in Washington Branch trains as above,	17,146·63	18,985·97	† 1,839·34
Total for tonnage transported,	$717,212·38	$647,509·48	* $69,702·90
Mail transportation in Main Stem trains,	40,613·87	40,664·00	† 50·13
Mail transportation in Washington Branch trains as above,	2,508·00	2,544·00	† 36·00
Total for mail transportation,	$43,121·87	$43,208·00	† $86·13
For use of cars on Winchester and Potomac Railroad,	4,299·09	3,922·91	376·18
For tolls collected at Harper's Ferry bridge,	2,276·89	1,983·75	293·14
Rent from Philadelphia Railroad Company, for Pratt street depôt,	1,500·00	1,500·00	
Total revenue from all sources,	$1,213,664·57	$1,101,936·58	$111,727·99

The aggregate revenue is, therefore, $111,727·99, or 10 per cent. in advance of that of the preceding year. Of this increase, about $\frac{5}{8}$ths is due to the tonnage, and about $\frac{3}{8}$ths to the passenger business.

The additional revenue from tonnage has been almost equally derived from the eastward transportation of produce and coal, and from the westward carriage of merchandize.

Of the increase of receipts from passengers, two-thirds has been derived from the local travel of the road, and but one-third from the western travel.

Expenses.—The cost of working the road is summed up as follows, under the foregoing heads, with the addition of "General Expenses," not therein embraced, and composed of salaries, house-rent, interest, insurance, law expenses, taxes, losses by casualties, and other incidentals:—

Summary of Cost of Working the Road.—Main Stem.

1. Maintenance of road, - -	$258,385·19
2. do. of machinery, - -	151,143·31
3. Conduct of transportation, -	215,614·34
4. General expenses, - -	20,626·35
Making a total amount of -	$645,769·19

The total expenses charged in the treasurer's accounts are $662,106·50;—more than the amount just stated by $16,337·31, which is due to materials

on hand for future use, and to the increase in a portion of them during the year.

The gross receipts of the year being $1,213,664·57, and the actual expenses $645,769·19, the nett earnings of the road were, consequently, $567,895·38, which is 8·11 per cent. upon the nominal capital of $7,000,000.

The expenses have been 53 $\frac{2}{0}$ per cent. of the entire receipts, as the two stand above. But if that share of the expenses incurred for improvements of a permanent kind, and forming no part of what is proper to be laid aside to cover depreciation, be treated as capital, then there should be deducted from the expenses above stated, the sum of not less than $50,000, thus reducing them so as to form but 48$\frac{3}{4}$ per cent of the gross receipts of the year.

Washington Branch.

Revenue.—The receipts of this road for the year ending Sept. 30, 1848, were as follows:

From passengers,	$194,740·20
From tonnage,	40,126·88
From mail,	10,032·00
Total receipts,	$244,899·14

Expenses.—The expenses above set forth are summed up as follows:

1. Maintenance of road,	$33,826·80
2. Maintenance of machinery,	16,256·47
3. Conduct of transportation,	26,865·89
4. General expenses,	10,325·00
Making a total of	$90,274·16
Leaving an excess of receipts amounting to	$154,624·98

And the proportion of expenses to gross income would be 37 per cent., and the profits would be 9$\frac{3}{8}$ per cent. on the capital of $1,650,000.

Trade of the Road.—Main Stem.

Eastward Trade.

General Produce.—It will be seen that the quantity of flour, grain, and meal, this year, is less than that of the last, by 163,760 barrels of the former, or 28 per cent.; and 5592 tons, or 60 per cent. of the latter. The increase in tobacco has, however, been 1422 hogsheads, or 35 per cent., and of provisions 881 tons, or 25 per cent.; of live stock, the increase has been 48 per cent., or 3969 tons; in whiskey, the increase has been 411 tons, or 60 per cent.; in lard and butter 263 tons, or 18 per cent. Iron has diminished 1529 tons, or 17 per cent. Granite, lime, and soapstone, have increased but 51 tons, being nearly stationary, and miscellaneous produce, such as leather, bark, fire-wood, fire-brick, iron ore, &c., &c., have increased 1715 tons, or 28 per cent.

Coal.—The amount of coal brought to Baltimore this year, has been 66,289 tons, being 16,030 tons, or 32 per cent., more than the last. The

means of transportation were adequate to a larger trade in this article than offered; the diminution of the demand, and various other causes, which must be of temporary continuance, having checked the operations of the mining companies of Allegheny county.

On the whole, the eastward tonnage arriving in Baltimore this year, has fallen 1041 tons short of last year, or about $\frac{5}{8}$ of 1 per cent., a reduction which, but for the coal trade, would have been much more considerable.

Westward Trade.

No detailed comparison with the previous year, in the various articles of this trade, can be made at this time, although that can be done in the next annual report, and afterwards. It may be stated, however, in the general, that there has been an increase of about 28 per cent. in the aggregate amount of merchandize of all kinds forwarded from Baltimore. The increase of transportation in that direction, is more to be desired than in the opposite one, whether we look at its effects upon the economy of transportation, or upon the revenue of the company and the trade of the city.

Passengers.

The number of passengers carried in the cars of the main stem, during the past year, from each station on the road, in each direction, is shewn in the appended table, lettered J, wherein is also exhibited the western travel to and from Pittsburg and Wheeling, Philadelphia and Baltimore, and the southern travel through Washington, as well as the local travel of the Washington road.

The aggregate in the main stem cars will be seen to be	160,974
While in the previous year it was	136,921
So that the increase has been (18 per cent. or)	24,053

Of the entire number of 44,538½ western passengers, 19,071½ have started from, or stopped in, Baltimore, and 25,467 have come from, or gone to, Philadelphia. Making proper allowances for the travelers, who, starting from, or bound to, Philadelphia, nevertheless halt in Baltimore, and for those who, doing the same by Baltimore, have yet come from, or were going to, Philadelphia, these facts will shew how much the value of the Baltimore and Ohio Railroad, as a passenger line, depends upon its character as a general thoroughfare between the Atlantic and the Western cities, independent of the travel proper to Baltimore alone. It will be seen that the travel through Pittsburg numbers 29,451 passengers, and through Wheeling 15,087 passengers, or about 2 of the former to 1 of the latter.

The revenue from the several classes of passengers, is relatively as follows:

From western passengers to and from Pittsburg and Wheeling, (per cent. 46·76,)	$207,964·50
From southern passengers to and from Washington, (per cent. 1·15,)	5,124·20
From other or local Washington travel, (per cent. 10·38,)	40,203·21
From local travel proper to main stem, (per cent. 41·71,)	185,961·83
Total revenue from passengers as before stated,	$445,254·34

Washington Branch.

Tonnage.—This, in the direction of Washington, consists of merchandize to that city, and limestone, &c., to the iron works on the line of the branch, or that of the Annapolis Railroad, and of cotton, &c., to the factories;—towards Baltimore, manufactured goods from these establishments, and of iron ore, iron, &c.

The number of tons hauled 1 mile upon the branch road, during the past year, was, eastwardly 610,078, and westwardly 629,679,—total 1,239,657 tons 1 mile, for which tolls were received. Adding to this the distribution of the company's fuel and materials, amounting to 67,729 tons 1 mile, the total movement will appear to be 1,307,486 tons 1 mile. This is an incrense of 212,664 tons 1 mile, or 20 per cent. over the previous year.

The revenue from freight has been $1596·26, or $4\frac{1}{10}$ per cent. greater than in 1847—about the same increase as last year.

Passengers.—The total number carried during the past year has been 170,196 for various distances, equivalent to 5,195,301 carried 1 mile. The southern passengers numbered 16,015 over the whole road, equivalent to 624,586 1 mile—and making about one-eighth of the whole number carried 1 mile, a smaller proportion than obtained last year. The revenue from passengers this year has been $35,338·21, or 22 per cent. more than last year, which may in a measure be due to the addition to the fare upon local travel, which constitutes seven-eighths of the whole passenger business of the road, and to the increase in which the improvement in the revenue of the year has been mainly owing.

A New Truss Girder.

The accompanying drawings exhibit the construction of a new trussed girder, the invention of Mr. John McArthur, Jr., a young and ingenious architect of our city.

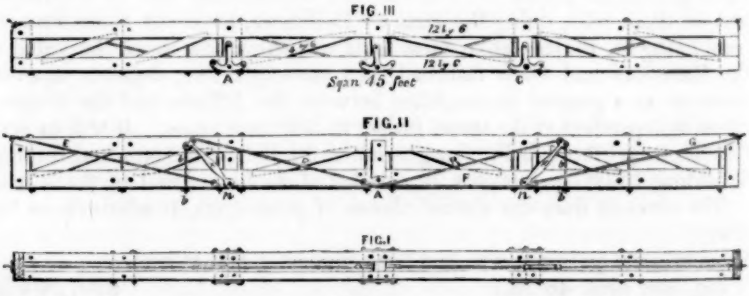


Fig 1 exhibits the plan, *a* and *b* being two separate girders, complete in themselves, trussed as in the elevation, (fig. 3.) Both these girders are securely bolted together, leaving a space between sufficient to clear the joints of the rods.

Fig. 2 is a section, showing one of the sides lifted off, exposing the suspension rods. The main rod, F, extends the whole length, furnished with

screws and nuts on both ends; this rod consists of three pieces, E F G; the piece F extends horizontally along the bottom of the girder, passing under and sustaining the bolts, N N, where a knuckle connects it with the parts E and G. The centre rod, R, is connected, on either side of the centre bolt, A, to a saddle which passes under the bolt, having a longitudinal opening in the centre, sufficiently large to permit the main rod, F, to come in actual contact with the bolt A; the centre rod, R, is brought to the required tension by the levers, X X, which are acted on by the perpendicular rods and screws, *b b*; these levers are also opened on the lower ends, admitting the main rod, F, to bear immediately against the bolts, N N, on which the levers turn. The bolts upon which the rods strain, are secured by wrought iron anchors on the outside, (see A B C, fig. 3,) $\frac{1}{4}$ inch thick, bolted through both sides. The main rod for a girder of this span, (45 feet,) is intended to be $1\frac{1}{2}$ inch iron; the centre rod $1\frac{1}{8}$ inch.

The following advantages are claimed for it:

First, It possesses scarcely any elastic motion when the weight applied is moving or at rest, consequently there is no danger to the bearing walls or ceilings.

Secondly, The strain, wherever the weight may be applied, is so distributed, that there is no liability to fracture in any one place more than in another.

Thirdly, Before the girder can deflect one inch in the centre, the main rod must lengthen a fraction over $\frac{3}{4}$ inch.

Fourthly, All the timbers used in the construction being small, there is less shrinking.

And, fifthly, Great economy in space; the whole elevation required for a span of 50 feet, being only 3 feet.

An experiment was tried on one of these girders, 45 feet in length between the bearings, in August, 1848. It was raised to its place on the walls, and a rod fitted accurately between it and the floor beneath; a weight of ten tons was then suspended immediately to the centre. It was found, by applying the rod, that the distance between it and the floor was still the same, shewing conclusively that no deflection had taken place, nor has any taken place since. Mr. McArthur is convinced that the result would have been the same, had a much greater weight been applied.

The cost of this girder was about $180. The dimensions of the timbers are marked on the accompanying drawing.

AMERICAN PATENTS.

List of American Patents which issued in the month of October, 1847, *with Exemplifications by* CHARLES M. KELLER, *late Chief Examiner of Patents, in the U. S. Patent Office.*

1. For an *Improvement in Lard Lamps;* Thomas Sewell, City of New York, October 2.

The nature of this invention consists in having a tube, which extends down into the lard, and placed between the two wick tubes, and opening

into them near the top, to conduct the heat given out by the flame or flames, to keep the lard in a melted state, and supply it to the wick or wicks, from the central tube, through the openings near the top thereof, whereby the lard, or other fat to be burned, is supplied to the wick or wicks in a more fluid state, than by any other arrangement with which I am acquainted.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the employment of a conducting tube, substantially as described, in combination with, and opening into, the wick tube or tubes, at and near the top thereof, for the supply of highly heated and fluid lard, &c., to the wick, substantially as described."

---

2. For an *Improvement in Water Wheels;* William Simpson and Horace Adams, Langdon, Sullivan county, New Hampshire, October 2.

Claim.—"What we claim as our invention, and desire to secure by letters patent, is the combination of the tapering channels, sunk in the plate, and the curved buckets, formed on the upper surface of the plate, and near its periphery, with the plate; the whole being combined, arranged, and operating in the manner and for the purpose set forth."

---

3. For an *Improvement in Flood Fences;* William Miller, Orrstown, Franklin county, Pennsylvania, October 2.

The patentee says,—"The nature of my invention and improvement consists in a new and useful mode of constructing panels of fencing, so that they shall rise by the force or power of a flood, or running stream of water, acting against them, and sliding over inclined planes, and turning on the lower rail, in the manner of a hinge, a quarter of a circle, and lying upon the surface, or in the water, and allowing the flood to pass over it, between the posts, without doing any injury to the posts, and when the flood has subsided, allowing the farmer, or other person, to raise the panel on its centre with very little trouble, to restore it to its position—the upper rail to be made V-shaped on the under side, and resting in corresponding notches or grooves, also made of a V shape, in the tops of the posts; the whole being made of clay burnt in a kiln of artificial stone, common pine or other boards, and chesnut posts and rails, or other more suitable, cheap, and durable material."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of the falling safety flood panel with the V grooved posts, constructed, arranged, and operating in the manner and for the purpose described: that is to say, I claim the combination of a rising and turning close panel, composed of two horizontal parallel rails, placed at a suitable distance apart, and united by vertical plates or boards—the upper rail being made of a V shape on the under side at the ends, fitted into corresponding shaped grooves made in the tops of the posts, so that when a pressure of water comes against the vertical boards, the said rail, with the boards, is caused to rise or slide up over the inclined sides of the notches to the top thereof, and back over the same in the direction of the running water, and fall down into the same, suffering the water to pass between the posts, without doing any injury to the fence;—the lower rail

being made with round tenons, that enter oblong mortises in the posts, a little wider than the diameter of the tenons, and considerably longer, so that the panel will be permitted to rise vertically, and turn therein in falling back, but will be prevented from leaving the mortises by the said tenons, until the flood subsides, when the panel is lifted to a vertical position and restored to its former place,—the parts composing the combination being made of wood, clay, moulded and baked, or of any suitable material for the purpose intended."

---

4. For an *Improvement in Smut Machines;* Daniel Pease, Jr., Floyd, Oneida county, New York, October 2.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the peculiar construction of the case, as described, being made in two sections, the one of small diameter, with ribs and perforated plates, extending beyond the sides, forming wind guides, the other section large and smooth, in the manner described, in combination with the revolving cylinder of large and small wings, corresponding thereto.

"Second, I claim the manner of arranging the openings for the discharge of the smut, with the sloped sides, protruding outwardly from the interior of the cylinder.

"Third, I also claim the construction of the receiver, having the triangular and rectangular guards, and the oblique space between them, in combination with the vibrating spreaders, arranged and operated in the manner set forth.

"Fourth, I claim constructing the spout with parallel vertical partitions, set in advance of each other, for the purpose of distributing the wind from the narrow fan in a broad sheet, in the spout, before reaching the grain in its descent from the spreader, as before described."

---

5. For an *Improvement in Composition for Door Knobs, &c.;* John Harrison, Stillwater, Saratoga county, New York, October 2.

The patentee says,—"This improvement consists in the use and process of compounding the following materials, viz:—1st, Bone, calcined, and pulverized, and ground, 10 parts; 2d, black flint, do. do., 4 parts; 3d, crystal felspar, do. do., 10 parts; 4th, granite, do. do., 10 parts; 5th, Vermont white sand, do. do., 10 parts; 6th, China clay, do. do., 11 parts; 7th, chromate of potash, do. do., 1 part; 8th, litharge, do. do., 1 part; 9th, antimony, do. do., 1 part; 10th, chrome green, do. do., 1 part; 11th, oxide of iron, do. do., 3 parts; 12th, oxide of tin, do. do., 1 part; 13th, oxide of zinc, do. do., 1 part; 14th, oxide of manganese, do. do., 4 parts. The above articles are calcined, pulverized, and ground in water, and constitute the body, and everything necessarry for the manufacture of articles."

Claim.—"I claim the application of the materials above specified, in certain proportions, and a specific and original method of compounding the same, as applied to the manufacture. I also claim to be the sole and original inventor, as applied to the manufacture of fossil granite knobs, candlesticks, knife handles, whip mountings, cane heads, &c., of the process from which they derive their peculiar beauty and excellence, combined

with the essential and desirable property of durability, inasmuch as atmospheric influence cannot, as in the case of the ordinary earthen knob, under any circumstances, deteriorate the essential properties of the compound."

---

6. For an *Improvement in Fire Arms;* L. H. Gibbs, Oberlin, Loraine county, Ohio, October 2.

The patentee says,—"The nature of my invention consists in making the breech stock of the gun tubular, the tube communicating with the breech of the gun barrel, for the purpose of receiving a number of shot-charged cylinders, in such a manner as that, as one is discharged of all its loads, it may be easily and quickly taken from the gun, as herein set forth, and another cylinder made to take its place, by simply dropping the muzzle of the gun."

Claim.—"What I claim as new, and desire to secure by letters patent, is the tubular breech stock, communicating with the bore of the barrel, for containing a series of shot-charged cylinders, combined with the springs, the retaining tumbler, the sliding discharging cover, the revolving tumbler, and the spring, substantially as set forth. I also claim the manner of pressing and retaining the shot-charged cylinders firmly against the breech of the barrel, by means of the tumbler, the screw-rod, the nut, and the lever, as set forth."

---

7. For an *Improvement in Cast Iron Chairs;* Jordan L. Mott, City of New York, October 2.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is, First, Making the seat of cast metal chairs or stools, concave or dished in all directions, from the rim towards a point midway, or nearly so, between the sides, and nearer the back than the front, to fit the anatomy of the body, and to give more support thereto, substantially as described; and, in combination therewith, I also claim making the seat thus formed of open work, for the discharge of water as described.

Second, I claim casting the seat with a depression in the deepest part of the concave, and covering it with a cap plate, the upper surface of which is a continuation of the curved plane of the seat, in combination with the plate or disk of the pedestal, made with holes, through which the cap plate can be secured to the seat, after the seat has been secured to the spindle on which it turns, and also for the escape of water that may leak through the joints of the cap plate, substantially as described.

"And, finally, I claim making the pedestal a hollow, in combination with a stake of corresponding form, driven in the ground substantially as described, so that it can be held permanently in place, and not affected by frost or change of seasons."

---

8. For an *Improvement in Looms;* Richard Collins, Cabotsville, Hampden county, Massachusetts, October 2.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is, First, The method of working the picker staves as described, by means of a worm, so constructed as to draw back the picker staves

gradually, during the whole revolution, by coming into direct contact with the staves; and throwing the shuttle by means of springs, constructed and arranged in the manner and for the purpose set forth.

"Second, I claim constructing the picker in the manner described, by forming a metal socket on the end of the picker staff, and inserting therein a piece of leather, or other suitable material, by which a cheap and substantial picker is made.

"Third, I claim the apparatus for moving the harness, consisting of a bottom roller, to which the harness is attached, which is turned by a segment rack, moved by an eccentric on the second shaft, substantially in the manner described, by which a great saving is made in the harness and warp, and the ordinary cam shaft is dispensed with.

"Fourth, I claim regulating the tension of the warp in the manner substantially as described, causing the weight gradually to approach the fulcrum of the shaft, by revolving said shaft or lever, on which a screw is cut for that purpose, in the manner set forth."

---

9. For an *Improvement in Making Splints for Baskets;* Abraham and Garret Van Riper, Bergen county, New Jersey, October 2.

Claim.—"What we claim as new, and of our invention, and desire to secure by letters patent, is the particular arrangement and combination of the respective parts, by which the reversing motion of the cutting knife is effected, and the machine thereby adapted to the cutting of stuff of different lengths, as set forth; said combination consisting principally of the vertical bar, attached to the stock or knife carrier, and the slide operating on the vertical posts, so as to cause the bar that embraces the belts, to shift said belts, under an arrangement of parts substantially the same with that herein set forth. We do not claim to be the inventors of a reversing motion, such motion being common to many machines, but we limit our claim as above set forth, to the particular combination by which we have adapted it to our machine, not intending, however, to limit ourselves to the exact form of the respective parts, but to vary these as we may think proper, whilst we attain the same ends by means substantially the same."

---

10. For an *Improvement in Distilling Turpentine;* R. F. Smith, Charleston, South Carolina, October 2.

The patentee says,—"The nature of my invention consists in providing a machine for accelerating the distillation and evaporation of substances subjected to heat, for saving from burning and discoloration, the gaseous and other evaporations, as well as the residues left after these are thrown off, and for the increased safety in the process of distillation, particularly of resinous juices, by checking their rising tendency in the vessels in boiling."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the application of the shaft, with its appendages, to the distillation of turpentine, in the manner described, or any other substantially the same, not confining myself to the form of the stirring apparatus."

11. For an *Improvement in Chronometric Locks;* John Y. Savage, City of New York, October 9.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the manner of securing the doors of bank vaults, safes, and other structures of a like character, by placing within such structure a time piece, which may be so set, as to cause the bolt or bar by which the door is fastened to slide back, under an arrangement of parts set forth: that is to say, by the action of the lever or arm, the roller, the pulley and weights, and the crank pin, operating on the bolt as set forth; the whole combination and arrangement being substantially the same with that herein made known; together with such variation in the form or connexion of the respective parts, as may be made therein without altering the principle of action, producing a like result by means substantially the same."

---

12. For an *Improvement in Grain and Straw Separators;* Hiram Berdan, Plymouth, Wayne county, Michigan, October 9.

The patentee says,—"The nature of my invention consists in combining an open and a close endless belt, revolving at different velocities, the one inside of the other, by which the grain is separated from the straw, after being threshed in a common threshing machine, and the straw conveyed from the machine, and the grain conducted to a fan or other place."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of an open and close endless belt, revolving the one inside of the other, at different velocities, for separating the grain from the straw, after being threshed; said conveyors operating in the manner and for the purpose described, by which the straw and grain are separated more effectually, and more rapidly, than by any other description of grain and straw separator in use; the straw being shaken and thrown from the machine, whilst the grain is delivered quietly into the conducting spout, without waste, by reason of this peculiar arrangement and operation of the conveyors as aforesaid, whilst the spaces between the slats are kept open and free, for the grain to pass through to the close conveyor, and the space between the conveyors prevented from clogging."

---

13. For an *Improvement in Machinery for Rolling and Twisting Iron;* Horatio Ames, Salisbury, Litchfield, Connecticut, October 9; English Patent dated 29th July, 1847.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is, First, The method herein described, of heating iron to increase its toughness or durability for certain purposes, such as railroad bars and ties, &c., by subjecting it, while in a highly heated state, to the compound operation of drawing and twisting, substantially as herein described.

"And I also claim in the machinery described, giving to one set of rollers a rotary motion on their axes, and a rotary motion, at right angles thereto, on the axis of the bar of iron, when this is combined with another pair of rollers that have simply a rotary motion on their axes, substantially as described, whereby the bar of iron, in a highly heated state, is drawn and twisted as described."

14. For an *Improvement in Cooking Stoves;* John T. Davy, Troy, Rensselaer county, New York, October 9.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of the flue between the fire chamber and the return flue, with the summer arrangement, in the manner set forth, and constructed substantially as herein described. I also claim the employment of the flue formed by the plate, (on,) in combination with the ventilator to the stove oven. Lastly, I claim the damper in the inclined piece, connected with the upper and lower fire or summer arrangement, for the purpose above described."

---

15. For an *Improvement in Jointed Pipes for Steam, &c.;* Lewis Kirk, Reading, Berks county, Pennsylvania, October 9.

The nature of this invention consists in making the pipe, which is in two parts, one sliding on the other, with the outer extremity of each part provided with two curved branches, connected by means of packed turning joints, with a vertical pipe having a closed journal at the upper end, and an open packed journal at the other, which forms the connexion, in one of them, with the steam chamber of the boiler, and in the other, with the steam chest of the engine; in this way the sliding of the two parts on one another, will admit of the vibration of the two carriages, towards and from one another; the packed joints of the branch pipes, with the vertical pipe, will admit of a free vibration vertically, and the turning of the short vertical pipes on their two journals, will admit of the free vibration of the two carriages, horizontally, while the union of the three will admit of vibrations in any direction; the curved branches of each part of the jointed pipe, which form connexions with the vertical pipes, effectually preventing any tendency to break or strain the joints in these parts, while the connexion of the two vertical pipes with the steam chamber and chest, by the two journals, effectually protect them against all tendency to break or strain.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is connecting the main pipe at each end, by means of two branches on opposite sides, when this is combined with the sliding joint in the main pipe, substantially as described, whereby the connexions of the main pipe with the vertical pipes, and the vertical pipes with the boiler and engine, or other vessels to be connected, are sustained against any tendency to strain or break, and the openings or passages are retained of the same required size at all times, while the two bodies thus connected are free to vibrate in all directions, without interrupting the flow through the pipe, as described."

---

16. For an *Improvement in Furnaces for Manufacturing Steel;* Simon Broadmeadow, City of New York, October 9.

The patentee says,—"My improvement in the structure consists in closing up the side flues, at the top of the coffer, and not allowing the flame to pass through them into the arch, but conducting it up each end of the coffer, (through temporary flues made when building up the ends after charging the oven,) into and along the arch to the centre, over which is the stack,

having a damper at the top, thus allowing the flame a greater opportunity of extending itself, and diffusing the heat more generally than by the old plan. When the fuel used in firing has partially spent itself, I nearly close the damper, by which means the heat is forced into the side or dead flues, and enables me to obtain a greater amount of heat from the same fuel, which would otherwise escape through the chimney."

Claim.—"What I claim as new, and desire to secure by letters patent, is the closing of the side flues at the top, and passing the smoke and flame through flues at each end of the oven, into and along the arch, to the centre, and thus into the chimney."

---

17. For an *Improvement in Ornamenting Book Covers;* William McAdams, Albany, New York, October 9.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the peculiar process of ornamenting the covers of books, as described: that is to say, by first indenting the outlines of the required figures on the covers, by metallic dies, to prevent the spreading and mixing of the colors, and then stamping the colors, by means of soft porous wooden stamps, made wall-sided, as set forth, by which the ends above stated are attained."

---

18. For an *Improvement in Doubling, Twisting, and Reeling Silk;* Frank Cheney, Manchester, Hartford county, Connecticut, October 9.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of a reel, by means of a band wheel, with a catch on its inner surface, and a cog wheel on the shaft of the reel, connected by an endless band with a doubling and twisting machine, for doubling and twisting threads of any kind, the whole so combined as to enable you to double, and twist, and reel threads, by the same machine, which machine is combined and operated as set forth."

---

19. For an *Improvement in Cap Cutting, and Levelling Leather;* Henry Underwood, Tolland, Tolland county, Connecticut, October 16.

Claim.—"I claim as new, the method of cutting caps, or scarfing leather, by a cam motion, single or spiral, applied to a gauge, in such a manner as to gradually decrease the thickness of leather drawn between it and a knife, making it tapering, and of any desired length; this motion, *i. e.* cam motion, being connected by gearing, gangs of pulleys, cones, or by any mechanical method, with the motion by which the leather is drawn through between the gauge and knife."

---

20. For an *Improvement in Portable Swings;* Charles Luxton, City of New York, October 16.

Claim.—"I do not claim the construction of the frame, pendulous arms, branches, nor swing car, they having been in use many years; but what I do claim as origiual, and desire to secure by letters patent, is the combination of the bent rod and cylindrical rollers, with the swing frame, car, and cords, as described."

21. For an *Improvement in Welding Cast Iron to Malleable Iron or Steel;* Mark Fisher and Wm. Martin, Jr., Newport, Penobscot county, Maine, October 16.

The patentees say,—"Our invention consists in the manner of forming the gates or jets, through which the molten iron passes into the flask, which is such as that it shall not be poured directly on to the piece of cast steel with which it is to unite, but that it shall flow over its prepared surface laterally, and be made thereby, as it were, to wash it; by this means fresh particles of the molten iron are brought into successive contact with every portion of the face of the steel or wrought iron, and whilst the flux protects the metal from oxidation, all foreign matter is completely removed, and the union of the two metals is perfect. In the moulding of some articles, it will be necessary to form a recess in the sand, to receive the waste metal that has been allowed to flow over the cast steel; but where there are a number of similar articles in the flask, every competent founder will be able to arrange the jets, as that the molten metal will pass from one prepared piece of steel or iron to the other in the first instance, and as the flask fills, the articles will be perfected without the necessity of any receptacle for waste metal."

Claim.—"We limit our claim to improvement to the so forming the jets, through which the molten iron passes into the flasks, as that the molten metal shall flow laterally over the surface of the prepared steel, or prepared wrought iron, for the purpose and substantially in the manner herein made known."

---

22. For an *Improvement in Cotton Presses;* Charles Gardiner, Richmond, Dallas county, Alabama, October 16.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the manner in which I communicate motion and power from the driving shaft to the platen, through the medium of the pinion, cog wheel, connecting arms, platen legs, and fulcrum bearing rollers, combined and operating with each other substantially as set forth."

---

23. For an *Improvement in Lubricating Compounds;* Lewis Kirk and John Dodsworth, Reading, Berks county, Pennsylvania, October 16.

The nature of this invention consists in mixing together, under a high degree of temperature, (say 500° Farenheit's scale,) whale or other oil, lard, or other like or equivalent substance, with coal tar or asphaltum, or with both.

Claim.—"What we therefore claim as our invention, and desire to secure by letters patent, is combining together, under a high degree of heat, whale or other oil, or lard, or other like or equivalent substance, with asphaltum, or with coal tar, or with both together, substantially as described, and thereby producing a compound for lubricating machinery which we find, by experience, to prevent friction and heating better than any other substance or substances known to us."

24. For an *Improvement in Planing Machines;* Andrew Caldwell, Lexington, Fayette county, Kentucky, October 16.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the manner in which I construct the planing or turning wheel, for operating on the surface of the plank, viz. giving the bit curved cutting edges at the ends, which serve as gouges or roughers, and double cutting or smoothing edges, extending from the curves at the ends, to a little past the centre of the same, and securing the bit to the face of a wheel, or cross head, substantially as set forth."

---

25. For an *Improvement in Reaping Machines;* C. H. McCormick, Steel's Tavern, Rockbridge county, Virginia, October 23.

The nature of this improvement consists in placing the driving wheel further back than heretofore, and back of the gearing which communicates motion to the sickle, which is placed in a line back of the axis of the driving wheel, the connexion being formed by means of a lever and connecting rod, thus placing the cog gearing, which operates the crank, forward of the driving wheel, for the purposes described, and also bringing the driving wheel sufficiently far back to balance the frame of the machine with the raker on it, and make room for him to set or stand on the frame back of the driving wheel, and with his back to the horses, so that, from this position, and the placing of the reel farther forward than heretofore, and making it shorter, together with the employment of a wheel board or guide, which prevents the grain from passing under the machine, or into the gearing, thereby avoiding the necessity of a long reel, he can rake off the grain with a sweep of his rake, (having the free use of his body and arms,) in a curve of which his body is the centre, and thus lay the grain on the ground with the heads outwards, at right angles to the swarth, which cannot be done if the raker walks on the ground by the side of the machine, as heretofore, for then the sweep which he makes with his rake, relatively to the motion of the machine, lays the grain on the ground with the heads oblique, instead of at right angles with the swarth, as with the improved mode.

Claim.—"What I claim as my invention, and desire to secure by letters patent, as improvements on the reaping machines secured to me by letters patent, bearing date the 21st of June, 1834, and the 21st of January, 1845, is placing the gearing and crank forward of the driving wheel, for protection from dirt, &c., and thus carrying the driving wheel further back than heretofore, and sufficiently so to balance the rear part of the frame, and the raker thereon, when this position of the parts is combined with the sickle, back of the axis of motion of the driving wheel, by means of the vibrating lever. And I also claim as my invention, the arrangement of the seat of the raker, over the end of the finger piece, which projects beyond the range of fingers, and just back of the driving wheel as described, in combination with, and placed at the end of, the reel, whereby the raker can set with his back towards the team, and thus have free access to the cut grain laid on the platform, and back of the reel, and rake it from thence on to the ground, by a natural sweep of his body, and lay

it in a range at right angles with the swath, as described, thereby avoiding unevenness and scattering in the discharge of the wheat, as well as accomplishing the same with a great saving of labor."

---

26. For an *Improvement in Sawing Hand Rails for Stairs;* John Brown, Memphis, Tennessee, October 23.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the mode of scribing and cutting hand railing for stairs and other purposes, substantially in the manner described: that is to say, by fixing the piece of plank from which the hand rail is to be cut, at the required angle of inclination with a horizontal plane, determined by the pitch board, or other means, and scribing with the awl applied to the plank, the required shape of the face mould designed for the twist or segment of the wreath of the desired hand rail, and then passing the saw through the same in the manner described, whether the several parts be arranged as described, or in any other mode substantially the same, by which analogous results are produced."

---

27. For an *Improvement in Laying Roving in Cans, &c.;* Joseph W. Strange, Taunton, Bristol county, Massachusetts, October 23.

The patentee says,—"The nature of my invention consists, First, In the combination with the coiling apparatus of a mechanism, by which the coiling apparatus may be revolved, so as to put any required degree of twist in the roving, before it (the roving) is introduced into the can. Second, In the manner in which I have combined and arranged together, three cams or hollow cylinders, and certain appendages thereto, by which I am enabled to introduce the roving into the interior of said cans, and pack it therein in eccentric helices. Third, In the manner in which I have combined and arranged three hollow cylinders or cans, and certain appendages thereto, by which I am enabled not only to introduce a sliver or roving into one of them, and pack it therein in eccentric helices, but at the same time put any required degree of twist in said roving."

Claim.—"Having thus described my improvements, that which I claim is the combination with the coiling apparatus, such mechanism, as will enable me to impart to the whole of it such a rotary motion on the vertical axis of the can, into which the roving is laid or coiled, as may be necessary to produce a twist in the roving as described. I also claim the manner in which I have combined three cans or hollow cylinders, and their appendages, consisting of the cap plate, toothed wheel, endless rack, applied to the outer can, together with the respective shafts and pulleys of the cans, or any mechanical equivalents therefor, so as to operate together, and lay or twist and lay the roving in a can, as specified, meaning also to claim, in its application to such a combination, the endless rack, whether made stationary, or so as to rotate as described, and whether applied to an outside can or other equivalent."

28. For an *Improvement in Bolts for Doors;* William Wheeler, Troy, New York, October 23.

Claim.—"Having thus fully described my new manufacture of bolts for doors, what I claim as new therein, and desire to secure by letters patent, is the making the whole of the instrument, with the exception of the sliding bolt itself, and the staple that is to be fastened to the door frame, of one piece of malleable metal, by bending the same, and by making a perforation therein, to receive, and to allow of the play of the knob, as set forth."

---

29. For an *Improvement in Machinery for Making Weavers' Harness;* Kassimer Vogel, Lowell, Massachusetts, October 23.

Claim.—"What I claim as new, and desire to secure by letters patent, is, First, The manner of arranging and combining the cylinders, so as to operate in the manner described, the yarn from the spools passing up to, and being wound on, said cylinders, as it is doubled, and twisted, and interlocked; the cylinders being also carried regularly forward, by means of the leading or guide screws, so that the whole harness is formed by the successive winding of the headles, and these respective combinations. I claim, whether the parts be formed and arranged precisely in the manner set forth, or in any other that is substantially the same in principle, effecting the same ends by means substantially the same. I also claim the combination of the respective parts of this apparatus, arranged as described, by which the respective threads are all doubled, twisted, and braided together, to the required extent, and then formed into two distinct coils, by doubling and twisting alternately, in the manner and for the purpose set forth."

---

30. For an *Improvement in Cotton Thinning Ploughs;* Winfield Crichton, Dimon Grove, Brownswick county, Virginia, October 23.

The patentee says,—"The nature of my invention consists in the construction of a cotton thinning plough, by which a cotton field may be cleaned and thinned, and regularly divided in hills, as described, by one operation of said plough, avoiding the troublesome and expensive slow mode of doing it by hand, and the hoe."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is placing the cutter in the rear of the driving axle and ploughs, and outside of the frame, as herein set forth."

---

31. For an *Improvement in Regulating the Speed of Drawing Heads;* Hugh MacLean, Paterson, Passaic county, New Jersey, October 23.

The patentee says,—"The nature of my invention consists in providing a more speedy and effectual means of changing the gearing, so as to give an increased or decreased speed to the front roller, so that an even and uniform thread shall be produced, whether one, two, or more cards are running, to produce the sliver even, without limit to the number of such cards."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the peculiar combination of the tubular shaft, with their gear and driving wheels, for giving to the front roller of "railway drawing heads," different rates of speed, without changing the velocity of the driving power; the whole being combined and operating as set forth."

---

32. For an *Improvement in Bedsteads;* Samuel Fahs and A. H. Seckman, York, Pennsylvania, October 30.

The patentees say,—"The nature of our invention consists in attaching the side or long rails to the posts, by means of hinges, so as to enable us to fold the bedstead together, and thus to carry it from one room to another, or, in case of fire, to carry it out of the house without taking it apart, and without taking off the cords or slats."

Claim.—"What we claim as our invention, and desire to secure by letters patent, is the particular manner of securing the side rails to the posts, by the combination of the hinges, the projecting irons or eyes, and the keys, viz. securing the hinges to the upper side of the ends of the rails, and the forming a recess in the under side of the same, for the reception of a portion of the eyes, for the purpose of securing the rail, and preventing the hinges from being warped and broken, by the springing and turning of the rail, when subjected to severe strain."

---

33. For an *Improvement in the Rotary Steam Engine;* A. & D. Buffum, City of New York, October 30.

Claim.—"What we claim as our invention, and desire to secure by letters patent, is the peculiar relative position of the revolver and the gate valve, during the passage of the point of the revolver by the face of the valve: to wit, the point of the revolver running in continuous contact with the face of the valve, and the opening edge of the valve, during the same time, (as at all times,) continuing in contact with the surface of the revolver.

"Secondly, The concave instead of the cylindric form of the central portion of the revolver, adapted to the application of a larger quantity of steam to act on the leverage of the revolver, and, at the same time, admitting such breadth to the ellipsis of the revolver, as to secure a very gradual and easy movement to the valves, and also allowing a more free escape for the expended steam.

"Thirdly, The location of the escape holes in the open vacuum space, between the outer surface of the central portion of the revolver, and the circle of the inner surface of the enclosing cylinder, in the plates which cover the ends of the cylinder, in combination with the revolver herein described."

---

34. For an *Improvement in Ship Building*; David Brown, City of New York, October 30.

Claim.—"What I claim as new, and as of my own invention, and desire to secure by letters patent, is the application of an auxiliary and internal iron frame, between the two thwartship ranges of material, forming collectively each principal frame timber of a ship or vessel, conjointly

with the constructive arrangement for rendering the same effective in place and use, including the fitting and use of the key, to act similarly to the key piece of an arch, and including any variations that may be practical conveniences, without effecting mechanical changes; all applied, constructed, arranged, and conjoined, substantially as described. The application of the lengthwise iron ribband ties, with their joints, the conjoining therewith the diagonal crossed braces, and the constructing and placing these parts, so that they shall be united to, and compressed into, close contact with the principal frame timbers, and the ends of the beams, by the bolt-formed ends of the lodging-ties, or the bolt-formed ends of the interior plate beams, receiving nuts by which these portions of the structure are secured together, including any variations that may be practical conveniences, without effecting mechanical changes, the whole applied, constructed, arranged, and conjoined as described."

---

35. For an *Improvement in Fastening Door Knobs;* William H. Mackrell, City of New York, October 30.

Claim.—"What I claim as new, and desire to secure by letters patent, is the constructing the screwed end of the spindle with a mortice or slot, to receive a screw or pin, screwed or driven through the neck of the knob, and the mortise, so as to be supported at both ends, for the purpose of adjusting the knob in place, and preventing the handle from turning on the screw, as described."

---

36. For an *Improvement in Manufacturing Wire Rope;* Edward S. Townsend, Trenton, New Jersey, October 30.

The patentee says,—"The nature of my invention consists in placing bobbins on radiating arms, projecting from a disk on the main shaft, which shaft is pierced with holes at its upper end, to receive the wires from the bobbins; through these holes the wires pass to ground rollers, (forming a tube adjustably weighted,) where they are firmly compressed and held, until, by the revolution of the main shaft, they are bent round each other to form a cord; by which arrangement, I, at this point, detect all imperfections in the wires, and am enabled to hold on, and splice and solder the same. From this point the cord formed is taken away, by passing it around an adjustable or changeable drum, (geered positively and adjustably,) which has tubing rollers, (like those before mentioned,) placed so as to hold the cord on the drum. By the first pair of tubing rollers I thus keep back the wild turn, yet allow the increased size of any part of the cord, (made so by soldering and splicing,) to pass the yielding rollers; and by the second set of tubing rollers, I produce greater adhesion to the drum which takes up the cord, gives greater uniformity to the laying of the twist, and rounds it as it passes on to a reel, which is connected to the foregoing machinery by belts or otherwise. In this way I succeed in making cord of good merchantable qualities, free of split, of blistered wires, and of wild turns, with an even lay of twist, round in form, and manufactured at a greatly increased speed."

Claim.—"What I claim as my invention, and desire to secure by letters

patent, is making wire cord or rope, by arranging the bobbins, with wire, on radial arms projecting at a suitable angle from a disk at right angles to the axis of the main shaft, by which the wire is fed and allowed one twist to every revolution of the main shaft, between the bobbins and the tubing rollers, as described, and thus obviating the complicated geering which would give the bobbins another revolution, contrary to the motion of the main shaft, to avoid any twist in the single wires; obtaining a greater speed and economy in manufacture, and preserving in the wire the turn, which bending the wires retains such a power, as detects those splits and blisters, or otherwise imperceptible defects in the wire, which would injure the cord, and thus doing this at such a time as is most convenient to mend them, and make a more perfect and reliable article, in a manner no wise injuriously affected as to the fibre of the wire; and in combination with this, that arrangement of tubing rollers, suitably weighted, which holds the cord as the wires are passed round in forming, keeping back the wild turn from the cord, and yet allowing the increased size of wires, from splicing or soldering, to pass the grooves by the yielding of the lever and weight; and in combination with these, the tubing rollers, suitably weighted, which bear upon the cord as it passes round the drum geered to haul off the cord, so as to cause greater adhesion between the drum and cord, giving greater uniformity in the lay of the twist in the cord, and rounding it as it passes to the reel, with which it is connected with bands or belts, the whole being constructed as set forth."

---

37. For an *Improvement in Machinery for Cleaning Snow and Ice from Railroad Tracks;* Samuel Streeter, Detroit, Michigan, October 30.

The patentee says,—"On a frame in advance of the driving wheel, and supported by burden wheels, is, first, the double conical surface, with flanches to remove heavy obstructions. The endless chain arrangement immediately follows, and removes the lighter substances, which have escaped the double conical surface, and immediately in rear of this, and in front of the burden wheels, is a wire spring broom, which passes over the track, cleaning it for the burden wheels; immediately in rear of the burden wheels, are bur wheels, to cut the ice which is often formed where the track passes through a gorge or deep cut; these wheels are raised or depressed by a lever which may be acted on by steam, and at the will of the engineer; immediately following this, is a double spring rotary scraper, also acted on by a lever. Any ice formed under the snow, or between banks of the same, can be removed by this, and the steam, if necessary, be made to act on the lever. Immediately in rear of this, and directly in front of the driving wheels, is placed a rotary wire broom, also acted on by a lever in a similar manner, and it is used to clean the track of ice or sleet, and to brush off the ice that may have been cut, or thrown, or left on, by the preceding cutters."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the mode herein described, of connecting and combining a series of machinery, for cleaning obstructions from railroad tracks, the whole being constructed, arranged, and combined and operating substantially as set forth."

38. For an *Improvement in Horse Powers;* Jonathan F. Barrett, North Granville, Washington county, New York, October 30.

The patentee says,—"The nature of my invention consists in the provision of ropes, to act upon a set of pulleys, combined as described, with the sweep and other parts for operation, and by which I effect the important object of saving a material part of the friction required in other horse power machines."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination and arrangement of the sweep with the semicircle, and other arrangements for letting off, and taking on, the belts, as well as the combination of these parts with the belts and drums, inclusive of their several operations, as set forth, for the purpose of a horse or other power."

---

39. For an *Improvement in Washing Machines;* D. Newton, Homer, Morgan county, Ohio, October 30.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the manner of combining and arranging the additional fluted board, pendulous rod, and connecting rod between the usual vibratory pressing board, and the end of the wash box, so as to have a simultaneous movement with the same, towards or from the middle of the wash box, as the end of the lever is raised and lowered, for squeezing and turning the clothes, at every vibration of the lever, between said swing boards, as set forth."

---

40. Eor an *Improvement in Water Wheels;* J. M. Abels, Cats, Cayuga county, New York, October 30.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the employment of a wheel, constructed so as to have the same quantity of water flowing through it at all times during its revolution, in combination with the valves on the breast of the shute, to prevent the escape of the water backwards, as herein set forth."

---

41. For an *Improvement in Boiler Plates for Cooking Stoves;* Charles J. Shepard, City of New York, October 30.

Claim.—"What I claim as new, and of my own invention, and desire to secure by letters patent, is the shape or form of the movable piece, as new in itself, and the combination therewith, of lift out pieces, of three different forms, to effect twenty or more different changes, such changes thereby producing the convenience of using seven different sizes of culinary or other domestic utensils, as described."

List of American Patents which issued in the month of November, 1847, *with Exemplifications by* CHARLES M. KELLER, *late Chief Examiner of Patents, in the U. S. Patent Office.*

1. For an *Improvement in the Portable Steam Pump;* William Boardman, Jr., City of New York, November 6.

Claim.—"What I claim as my invention, and desire to secure by letters

patent, is the combination of the steam engine with the two pumps, as set forth, viz: placing the steam engine cylinder between the two pump cylinders, with the piston rods of three cylinders all connected to the same cross head. I also claim the combination of the steam engine, and the pump cylinders, (connected as set forth,) with the hollow supporting beams, serving as water ways to the pump cylinders, as set forth. I also claim the combination of the steam engine and pump cylinders, with the hollow beams, or induction water ways, and the eduction chambers or water ways, the whole constructed, arranged, and operating as set forth."

---

2. For an *Improvement in the Washing Machine;* William Younger, Huntingdon, Carroll county, Tennessee, November 6.

Claim.—"What I claim as new, and desire to secure by letters patent, is the combination, with the driving roller, of the toothed roller, fluted roller, and rubbing board; the board rubbing the clothes, and the rollers pressing upon and changing the position of the clothing, as they are revolved, substantially in the manner set forth."

---

3. For an *Improvement in Disconnecting Railroad Trains;* Richard Hemming, Boston, Massachusetts, November 6.

The patentee says,—"The object of this invention is to enable the brakeman or conductor of a train, to disconnect one or more cars from the train, or the whole train from the engine, at will and instantaneously, without incurring the risk or inconvenience attendant upon the present system of coupling."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is an apparatus for disconnecting railroad cars, by the use of the movable jaw, the lever, and the bolts, operating in connexion with the lever and the springs, in the manner set forth."

---

4. For an *Improvement in Washing Machines;* Joseph Hall, Otisfield, Cumberland county, Maine, November 6.

The patentee says,—"The operation I perform by means of a crank, attached to the upper fluted cylinder, which causes the apron upon which the clothes are laid, to revolve over the small rollers, and to pass between the fluted cylinders, where they receive the crimping, rubbing, and squeezing operation, and thence are carried to the opposite end of the box, where they are again saturated with water, and by a reversed motion of the crank are brought back, and again made to pass between the wash cylinders, and this is continued until the washing is completed."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of the revolving endless belt and fluted rollers, substantially as set forth."

---

5. For an *Improvement in Chimney Caps;* William Creutzfieldt, Washington City, D. C., November 6.

The patentee says,—"The nature of my invention consists in furnishing

a smoke or ventilating flue, with an apparatus that shall cause a current constantly up said flue, by means of inclined revolving wings, that are put in motion by the wind when blowing in any quarter, without a directing vane, or other apparatus, that are always liable to be blown down by a high wind."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the revolving chimney cap, constructed as described, having spiral wings placed over a flue within a short cylindrical case, on the outside of which are wings, acted on by the wind, by which the whole are caused to revolve when the wind is in any quarter, without a directing vane, as specified."

---

6. For an *Improvement in Stuffing Boxes;* Thomas W. Allen and Charles W. Noyes, Green Bush, Rensselaer county, New York, November 6.

Claim.—"What we claim as our invention, and desire to secure by letters patent, is not the employment of metallic packing in a stuffing box generally, but the employment of metallic packing, arranged, shaped, and combined in a peculiar way, viz: in a metallic matrix or cup, shaped and arranged so as to allow the piston rod or shaft, passing through the stuffing box, liberty to vibrate laterally to a sufficient extent to meet the unavoidable irregularities of the engine to which it may be applied, and at the same time support within it, conical shaped metallic rings, moving against and along the piston rod or shaft, as well as against and along its (the cups) oblique surface, so that, as the inner surface of the packing rings wear away, the rings may, by the proper application of springs or screws, pressing them in the direction of the axis of the piston rod or shaft, be advanced along the conical surface of the matrix, so as to maintain a perfect contact of surface, both with the piston rod or shaft, and with the matrix. We also claim the use of the said vibrating cup, without the metallic packing, in which case we use hempen or other packing in connexion with it."

---

7. For an *Improvement in Machinery for Drilling Rock;* P. T. Wightman and H. Vaughan, Greenwich, Kent county, Rhode Island, November 6.

Claim.—"What we claim as our invention, and desire to secure by letters patent, is the combination of the drill described, with the wheel and inclined block, by means of the cord, whereby the drill is elevated, turned, and dropped."

---

8. For an *Improvement in the Construction of Combination Locks and Keys;* S. L. Chase, Lockport, Niagara county, New York, November 6.

Claim.—"What I claim as new, and desire to secure by letters patent, is, First, A series of concentric revolving tumblers, in connexion with which are placed a similar set of revolving wards, which are attached thereto, so as to be placed in a variety of positions in relation to the tumblers, in the manner described, and so constructed that they can be turned without being deranged, in an attempt to pick the lock, but cannot be put into position to construct a false key, or be unlocked by the proper key,

without it is set to the proper numbers on the index to which the ward will correspond; the whole being constructed as set forth.

"Secondly, I claim the method of fastening up the key-hole, by means of a movable escutcheon and catch bolt, as set forth, in combination with the apparatus for forcing the tumblers, for farther change of position, in drawing the bolt.

"Thirdly, I claim throwing the projection on the bolt into the centre of the tumblers, as described, so that the wards can be disarranged when the door is unlocked, to prevent an impression being taken from them.

"Fourthly, I claim the key for setting the revolving tumblers, constructed as described, having a series of concentric indexes, for setting the disks and bits, which are then firmly connected by a screw bolt passing through the centre of them, as set forth."

---

9. For an *Improvement in the Railway Car Wheel;* Frederick Harbach, Pittsfield, Berkshire county, Massachusetts, November 6.

The patentee says,—"My improvement consists in the employment of a third circular plate, which I arrange between the circular plates, and which I cause to extend from a solid hub to the rim, and be connected to, or cast with or to, said hub and rim, in the same manner as are the other plates."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of the middle plate with the two outer plates, and hub and rim, in the manner and for the purpose set forth."

---

10. For an *Improvement in Car Wheels;* Frederick Harbach, Pittsfield, Berkshire county, Massachusetts, November 6.

The patentee says,—"The nature of my improvement consists in the manner in which I make the hub, viz: with a contractible chamber, whereby I can cast or found it, and not only obtain all the advantages of a solid or cylindrical hub, extending from one of the side plates to the other, but all those of a divided hub, without any of the disadvantages of the latter."

Claim.—"I claim the improved mode of making that part of the hub which is between the two side plates of the wheel, viz: with a lateral expansion and chamber, and in other respects substantially in the manner and for the purpose specified."

---

11. For an *Improvement in Ice Cutters;* J. B. Wilson, Malden, Middlesex county, Massachusetts, November 6.

The patentee says,—"I form in the rear of the cutting edges of each chisel, a supplementary chisel, by grooving out the side of the chisel plate, and making of said groove a vent for said supplementary chisel, which shall increase in width as it retreats and opens into the discharging vent of the next main chisel."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the supplementary chisel, and its discharging vent, as combined with, or applied to, each of the main chisels, and the discharging vent of the chisel in rear of it, the whole being substantially as specified. I am

aware that ice cutters have been made with guides, hinged or so connected with them, as to be caused to rest and move in a parallel groove to that which is to be cut; and therefore I do not claim a guide so combined with, or arranged upon, the ice cutter; but that which I do claim, is the rudder or guide, as applied in the rear of the ice cutter, and combined with it in manner as described, and for the purpose of causing the ice cutter, by the aid of the groove it is cutting, to cut in a straight direction."

---

12. For an *Improvement in Hillside Ploughs;* Wm. H. Babbitt, Waynesborough, Green county, New York, November 6.

Claim.—"What I claim as new, and desire to secure by letters patent, is the swivel joint, which connects the sheath of the plough with the beam."

---

13. For an *Improvement in Horse Shoe Machines;* P. P. Read, Durham, Cumberland county, Maine, November 13.

Claim.—"I do not claim the invention of making horse shoes, by bending the bar iron that forms the shoe, around a horse-shoe-shaped former, and pressing the crease and nail holes; but what I do claim, is the particular manner of combining the sliding horse-shoe-shaped follower, or fuller, for bending the bar of iron around the former, to form the horse shoe, with the horse-shoe-shaped die, and spring bar, connected therewith, for stamping the crease and nail holes in the shoe, by the sudden blow of a falling weight, which again rebounds from the shoe, as soon as the weight commences to rise by the action of the windlass, rendering the fibres of the iron of which the shoe is composed, close, compact, tough, and lasting; the several parts of the said combination being made, arranged, and operated substantially as set forth."

---

14. For an *Improvement in Apparatus for Inhaling Ether, &c.;* W. T. G. Morton, assignee of Augustus A. Gould, Boston, Massachusetts, November 13.

Claim.—"Having thus described our improved apparatus, that which we claim as new, and wish to secure by letters patent, is the system of induction and eduction valves, and openings of the mouth tube, (or any mechanical equivalent for such valves and openings,) in combination with said tube and the vessel, and made to operate therewith, in the manner described, We also claim the supplying reservoir or apparatus, in combination with the evaporating vessel, the same being arranged and operating as set forth. We also claim the supporting or lip flanch, as combined with, or applied to, the mouth piece of the tube, and operating therewith in the manner set forth. And for the purpose of inhaling a due portion of atmospheric air, while breathing the etheric vapors, and preventing the escape of the vapors when the apparatus is not in use, we claim, in combination with the reservoir, an air inlet or tube, and its valve, the whole being combined and operating as specified. And we also claim, in combination with the vessel, and its air inlet and exhaustion pipes or contrivances, a sponge, or the equivalent, operating by capillary attraction, or otherwise, to expose an

extensive surface of liquid to the evaporative action of the air passing through the vessel."

---

15. For an *Improvement in Bridges;* Stephen H. Long, Louisville, Jefferson county, Kentucky, November 13.

Claim.—"What I claim as new, and desire to secure by letters patent, is the method of trussing, or straining the truss frames of bridges, and other analogous structures, in the manner and by the means set forth: that is, by inserting and driving keys or wedges between the posts or vertical ties, which are stationary, and the bolsters or gluts, which are movable; whereby the said bolsters, or the said gluts, together with the ends of the main thrust braces, may be made to slide along the strings; and the requisite straining or trussing may be produced, and imparted to the truss frames, without changing the relative positions of the strings, posts, or main suspensor braces.

"I also claim the application and use of the extra or auxiliary braces, in connexion with the posts and main suspensor braces, and abutting against the string pieces in the manner set forth, for the purpose of strengthening, stiffening, and otherwise fortifying the truss frames of bridges.

"The several arrangements and combinations of parts and principles, contemplated in the specifications and claims, together with the various actions and operations, are to be regarded as distinguishing features of my composite bridge, when compared with those of other bridges."

---

16. For an *Improvement in Machinery for Ascending and Descending Inclined Planes;* George E. Sellers, Cincinnati, Hamilton county, Ohio, November 13.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the method of increasing the tractive power of the locomotive engine, by the resistance or gravity of the train to be drawn thereby, by connecting such train with the driving wheels that gripe the central rail. I also claim the connecting of the wheels that gripe the centre rail, and which act thereon as drivers, with a spring substantially as described, whereby the required adhesion can be obtained when the locomotive is ascending or descending an inclined plane, without a train of cars, or when, by accident or other cause, the resistance or gravity of the train cannot be employed for this purpose. I also claim the forming of the connexion between the gripping wheels and the train, by means of two opposite toggle-joint levers, connected with the levers of the gripping wheels, as described, whereby the train is made to act on the gripping wheels, either in ascending or descending inclined planes, as described. I claim the connecting of the two gripping wheels with the frame of the locomotive, by means of levers, substantially as described, whereby the locomotive is left free to vibrate between the track rails, whilst the gripping wheels are acting on the central rail, thereby relieving the central rail from being affected by the surging of the locomotive from side to side.

"And finally, I claim the combining of the gripping tongs with a railroad car or cars, by means of the arms of its levers, and by chains, or jointed rods, as described, whereby the pull of the cars, on running down an in-

clined plane, in the event of the breaking of the connexion with the locomotive, or of the cars with each other, will act on the tongs, and cause them to gripe the rail, as described."

---

17. For an *Improvement in Building Ships*; Richard F. Loper, Philadelphia, Pennsylvania, November 13.

The patentee says,—"The nature of my invention consists in constructing the frames of ships and other vessels of bars of plate metal, connected together by bolting to them the wooden ceiling, the keel, and stern posts, whereby I am enabled to make a vessel of greater strength, with a given weight, than can be attained by wood alone, and prevent the corrosion which takes place when the outside of a vessel is made of iron."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is constructing ships and other vessels with hollow iron ribs, rolled as described, and bound together by means of a wooden planking and ceiling, substantially as described, whereby a great saving in weight and cost of metal is effected, said hollow ribs affording a means of introducing oil, which, by the motion of the vessel, is made to circulate and penetrate to the bolts and fastenings, preventing the rotting of the planks, and the oxidation of the metal, as described."

---

18. For an *Improvement in Cotton Cleaners;* John Wind, Thomasville, Thomas county, Georgia, November 13.

Claim.—"What I claim as new, and desire to secure by letters patent, is placing the beating wings in a continuous helical direction, upon a conical skeleton cylinder, and combining the same with a skeleton concave and casing, substantially in the manner and for the purpose set forth."

---

19. For an *Improvement in Alarms for Steam Boilers;* H. B. Fernald, Boston, Massachusetts, November 13.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combining of a float within a steam boiler, with a case into which water is to be admitted, through apertures in its lower part, and with a steam whistle, said float having a valve at its upper end, surmounted by a steam whistle; the whole being constructed and arranged as set forth."

---

20. For an *Improvement in the Manufacture of Bullets, &c.;* George W. Campbell, Belleville, Essex county, New Jersey, November 20.

The patentee says,—"The nature of my invention consists in connecting, in an endless series, the sections of a bullet mould, and causing them to pass around two or more rollers, or carrying cylinders, in such a manner as that their weight shall hold them together tightly closed, and on bending round the cylinders, the sections shall be opened, so as readily to free and discharge their contents."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is an endless chain of sections or moulds, passing over horizontal prisms on cylinders, as specified, for making bullets and other castings, so that the sections of the moulds shall be forced open, for the discharge of their contents, by passing around said cylinders."

21. For an *Improvement in the Percolating Apparatus;* C. Augustus Smith, Cincinnati, Hamilton county, Ohio, November 20.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the process of extracting the medicinal or other valuable properties from vegetable substances, as described, viz: placing the vegetable substances in a percolator, passing a current of steam or vapor into the same, and gradually condensing the steam or vapor, while it is diffused amongst the vegetable substances, by means of a suitable condensor, combined with the percolator, as set forth."

---

22. For an *Improvement in Machinery for Preparing Husks for Mattrasses;* Adrian Olcott, Newark, Essex county, New Jersey, November 20.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of the machinery by which the husks are held and knobbed, as described, and also the combination of the machinery by which the husks are slit and cleaned, as set forth."

---

23. For an *Improvement in Grinding Mills;* E. Harrison, City of New York, November 20.

The patentee says,—"The principal peculiarities and improvements consist in the arrangement, by which a strong current of air is passed in contact with the external surface of the stationary grinder, to prevent it from heating."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of the fan drum with the stationary grinder and casing, substantially as described, for cooling the mill and cleaning the grain."

---

24. For an *Improvement in Window Sash Fasteners;* James Haggart, City of New York, November 20.

The patentee says,—"This fastening consists in part of a vertical metallic rod, which is attached to the centreward side bar of a hinged sash, by staples or straps, and terminating in a snail catch at each end, which occasionally takes to a small staple attached to the window frame or casement above; and to the central part of the rod is attached an arm, by which the position of the rod is changed, (occasionally,) and to the end of which is attached a handle and catch, whereby the arm is occasionally made fast to the socket plate, which is attached to the centreward side bar of the sash, which constitutes the other half of the window."

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the arm with the handle and catch, in combination with the metallic rod and the catchers, as described."

---

25. For an *Improvement in Bog Cutters;* Robert Cummings, Lima, Lagrange county, Indiana, November 20.

Claim.—"What I claim as my invention and improvement, and desire to secure by letters patent, is the combination of the angular knives and

revolving knives, in the manner described. I also claim the hooks, constructed and operating as described. And I claim, lastly, the combination of the roller with the hooks and knives."

---

26. For an *Improvement in Heating Water for Bathing;* Richard H. Hobbs, Hartford, Connecticut, November 27.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the combination of a self-acting receiver and boiler, constructed as described, for the purpose of supplying hot and cold water, for bathing and other similar purposes, the receiver being connected with the boiler by a syphon, and having gauge pipes in its sides, for regulating the quantity of water discharged at one operation, and the boiler having its discharge pipe situated so far above the bottom, as to retain a sufficient quantity of water to fill it, and the receiver, with steam, for a renewed operation, as described."

---

27. For an *Improvement in Spinning Machinery;* George H. Dodge, Attleboro', Bristol county, Massachusetts, November 27, in America; and in Scotland, September 27.

Claim.—"That which I claim is as follows: I claim the combination of mechanism, by which the scroll shaft has a partial rotary forward motion imparted to it, and is allowed to fall or move backwards, the same consisting of the standard, or any equivalent therefor, the bent lever, the spring dog, the clutch or dog wheel, or their mechanical substitutes; the whole being arranged, applied to the scroll shaft, and operated together as specified. And, in combination with the aforesaid shaft, and machinery for imparting to it its rotative motion or motions, I claim the cam, and chain, and machinery, for connecting said shaft with the ring rail or rails, or any mechanical equivalents therefor, the whole being for the purpose of raising the ring rail or rails, and suffering it or them to fall down, for the purpose of laying or binding thread over each layer of thread of each of the cops, as specified. I further claim the combination of mechanism, by which I am enabled to regulate the length of each successive layer of yarns composing the cop, the same consisting of the cam, and made to rotate, or partially rotate, on the scroll shaft, as described; the warm gear, endless screw, shaft, frame, ratchet wheel, vibrating lever, impelling pawl, lever, standard, projection, and rod, extending downwards from the ring rail, or their mechanical equivalents; the whole being combined and made to operate substantially as specified.

"I further claim, in its application to the scroll shaft, the combination of mechanism by which the fall of the ring rail is regulated, in such manner as to prevent it from descending too suddenly, so as to break any of the yarns, the said mechanism consisting of the fly wheel, and machinery for rotating it, as applied to the scroll shaft, and made to operate in connexion therewith, as specified.

"And, for the purpose of causing the ring rail to rise upwards, with the increased velocity necessary to prevent the yarn from piling too much in any one place, and thereby destroying the conical form of such layer of yarn

composing the cop, I claim the cam, lever, and roll, or any equivalents therefor, as combined with the scroll shaft and chain, and made to operate substantially in manner as before explained. And in combination with said machinery, I claim the projection applied to the cam, for the purpose of producing a very quick rise of the ring rail, in order to finish the nose or upper extremity of each layer of yarn composing the cop, in the manner specified.

And I also claim the manner of making each of the spindles, in order that it may be elevated so as to carry a broken end of yarn above the ring rail, so that an attendant may readily seize it, to piece or join it to the thread proceeding from the draw rollers, without being obliged to wait for the ring rail to fall downwards. And I also claim to construct the spindle, directly beneath that part of it on which the cop is formed, of a diameter proper to produce the lateral drag on the traveler, sufficient to overcome its inertia, and impart to it a velocity necessary to prevent the yarn from being broken, in combination with making that part of the spindle on which the cop is formed, smaller in diameter as specified."

---

28. For an *Improvement in Looms for Weaving;* James Nield, Taunton, Bristol county, Massachusetts, November 27.

Claim.—"That which I claim, is the combination of two revolving series of shuttle boxes, applied respectively to both ends of the lay of the loom, and made to rotate forwards and backwards, or operate together, in manner as specified. By the employment of two revolving series of shuttle boxes, instead of rising and falling ones, very important advantages are gained in their combined operation. When a series of boxes is composed of four or more, and they are arranged the one over the other, so as to rise and fall, if a shuttle is to be thrown from the first box, and be succeeded by one in the last box, the whole of the series must be gradually raised upwards, or depressed, as the case may be, before the shuttle of the last box can be ejected therefrom. This requires a great waste of time. Now when the series are arranged around a revolving axis or shaft, or what are termed revolving boxes; the first box of the series may be said to lie directly alongside of the last one.

"To throw the last shuttle, the series would only require to have its movements reversed the breadth of one box; thus it will be seen that a great saving of time can be effected in "shot about" weaving.

"The arrangement of the boxes around an axis, to revolve, enables me to bring many of them into action much sooner, or with more dispatch, than when they are arranged in line with each other, and the one over the other, and are made to rise and fall vertically. I also claim the pattern belt of changeable wires, external and central links, as made, combined, and applied together, and to a sprocket wheel, or other equivalent, as specified, in combination with the reversing arms, and supplementary wires of the pattern belt, or other equivalents, as combined with the apparatus or mechanism for rotating either series of shuttle boxes; said arms and wires being for the purpose of reversing the motions of the boxes, as specified. I consider the combination of a circular plate, and changeable screw pins inserted in it, and as applied and used in manner set forth, as a mechanical equivalent for the pattern belt above described. I also claim

the weighted lever and pin, or any equivalent therefor, in combination with the lever and stop motion of the loom, the same being for the purpose of arresting the motion of the sprocket wheel and pattern belt, or the pattern plate, when a filling thread breaks, as set forth. I also claim one or more inclined planes or cams, as applied to, or combined with, the lower frame or lay, and revolving series of shuttle boxes, for the purpose herein before specified. I also claim the contrivance for elevating the loose filling, or weft threads, out of the way of the stop motion of the loom, the same consisting of the arm, as arranged and operated substantially as specified. I also claim the combination of pins, notches, or other similar contrivances, with the front end of the revolving series of shuttle boxes, in the manner and for the purpose substantially as set forth."

MECHANICS, PHYSICS, AND CHEMISTRY.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Paddles of Steamers—their Figure, Dip, Thickness, Material, Number, &c. *By* THOMAS EWBANK, ESQ., *City of New York.*

The world is awakening to the propulsion of steam vessels, and nations are about to compete with each other in increasing their speed. Steamboat racing is too congenial with the age to be repressed; its spirit, so far from having been laid by legal exorcisms, or confined, as heretofore, to lake and river craft, has now seized the ocean for its theatre, and laughs outright at adjurations. Engineers and naval constructors, animated with the ambition of Olympian competitors, are preparing for a series of Atlantic chariot races, compared with which, the whole Naumachian spectacles of old were despicable puerilities.

Impressed with the interest of a contest unexampled in the annals of mechanical science, and one so characteristic of the progress of civilization, the following experiments were undertaken with a view of eliciting facts that seemed imperfectly known. Speculations on propelling abound. I am not aware that a series of experiments similar to these, limited and imperfect as they are, has been prosecuted. If any such are recorded, I have not met with them.*

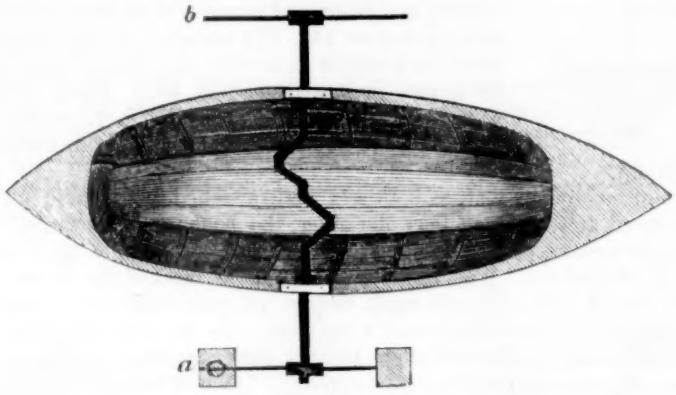
Experiments on variously formed Paddles, made on the Harlem River, New York, in 1845 *and* 1848.

For this purpose, the boat, fig. 1, was employed. It was 12½ feet long, and 3½ feet across the middle. A wrought iron shaft, 1 inch square, with a crank, extended across the gunwales, and turned in bearings bolted to them. The ends of the shaft stretched 14 inches over the sides of the boat. This prevented the wheels, which were secured on their extremities, from throwing as much water into the vessel as if they had been nearer; and afforded a better opportunity of observing the action of the blades. A person seated at one end of the boat, readily turned the wheels, in either direction, by alternately pushing from, and pulling towards, him, two upright rods,

* See the note at the end of the article.

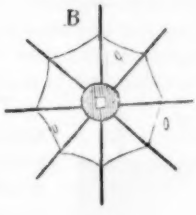
which moved in joints at the bottom of the boat, and were connected to the cranks by horizontal rods or pitmen.

Fig. 1.



The wheels were very light, and of the simplest construction. One is figured at B. Eight slender arms, of $\frac{5}{16}$ square iron, have their inner ends cast in the central piece. They extended 20 inches from the centre, and thus made a 40-inch wheel. To stiffen them, and transmit any strain upon one to the whole, they were braced tightly together by the wire, *o*, *o*, *o*, fig. 2, which was wound round each arm, and retained by slight notches at the corners. The various blades or paddles were cut out of stout sheet iron. Square sockets, to slide over the arms, were riveted to them; by which means they were readily adjusted and secured at uniform distances from the axes. All were of the same area—49 inches.

Fig. 2.



To test the qualities of the boat, and get her into working trim, blades, 7 inches square, fig. 3, were fixed on the arms of both wheels, and several excursions, up and down the river, made with them. Their dip was 7 inches, or rather more, for their upper edges were half an inch below the surface. They were next removed from one wheel, and left on the other, as the standard by which to compare the effects of different shaped ones.—They were distinguished as No. 1. Nearly all the rest were formed from them: *i. e.* by removing portions from one part, and adding them to others, as will be seen in the following diagrams. In this way there was no danger of making, through mistake, one set of blades, of larger, or of less, superficial surface, than others—since no calculation of their areas was required.

3

In all the figures, the paddles are supposed to sweep through the water

in the position they are represented in, the lowest sides being those which descend lowest in the fluid.

4

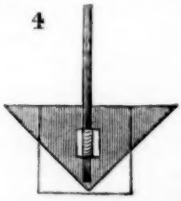


Fig. 4,—formed by cutting off the lower angles of fig. 3, and transferring the pieces to the upper ones, making a right-angled triangle, with sides 10 inches, and hypotenuse 14. (By mistake, the upper corners were cut away, so as to leave the area of these blades 48 square inches, instead of 49.) Eight of these were fixed on the wheel, (see *b*, fig. 1,) to compete with the same number of fig. 3, on *a*, both having 7½ inches dip.

It will be obvious that, as both sets were attached to the same shaft, if one proved more efficient than the other, the boat would be turned from a straight course, and be inclined, more or less abruptly, to the weaker, or less efficient set. The result was, that those marked fig. 3 overcame fig. 4; and though only in a small degree, yet quite sufficient to establish their superior effect on the vessel's progress. As we were not always out of the influence of tides and slight breezes, each experiment embraced excursions in various directions on the river. Once or twice, the boat went straight as an arrow, but eventually, the square paddles got the better of the triangular ones. These dipped into the water with little noise, and threw it off behind from their points.

Most of the experiments were made in smooth water, and, except slight currents—aqueous and aerial—under the most favorable circumstances. Two persons occupied the boat, and the greatest care was exercised in preserving the shaft in a horizontal position. When results were doubtful, the experiments were repeated, and, generally, several times.

5

The *same* paddles (fig. 4) were next attached to the arms in the position represented in the margin, and distinguished as fig. 5, the upper side being, as in all other instances, 13 inches from the centre of the axis. Through repeated trials, they overcame the test paddles, fig. 3, and in a rather more marked manner than fig. 3, surpassed fig. 4. They entered the water silently, but observers on shore thought they raised more water behind, but did not raise it as high as fig. 3. Their points were nearly 3 inches lower in the water than the lower edges of fig. 3. The boat described a circle of 400 feet, and another of 600.

6

The same blades were next tried as fig. 6. From the experiment fig. 5, it was inferable that, if inverted, the effect of the blade on the boat would be augmented, as a larger portion would have a longer sweep through the water. Such was the fact, and to such a degree, that first two, and then four, were removed from the arms, when the remaining four were found equal to the eight of fig. 3. The plates were next raised, till their lower edges were on a level with those of No. 1. In that position, two inches of their upper extremities were above the surface of the river; but, notwithstanding, they had a decided advantage even then, over the square ones.

Lastly, the same blades were turned into the position of fig. 7, (being fig. 4 reversed.) The boat was turned on No. 1 under all circumstances, describing circles from 80 to 150 feet in diameter. Four of them equalled eight of No. 1. They were thought to throw off more water behind than their competitors, which, from the greater extent of their extremities, is probably true.

The next form tried was fig. 3, placed in the position of fig. 8. These turned the boat round against the test ones, in circles varying from 50 to 200 feet. We then tried six of them against the other eight, when there was little observable difference in the results. Four were found superior, but three were unequal to them. These, of course, entered the water, without jarring, and threw it off at their points. Mr. B. thought they threw up more than fig. 3.

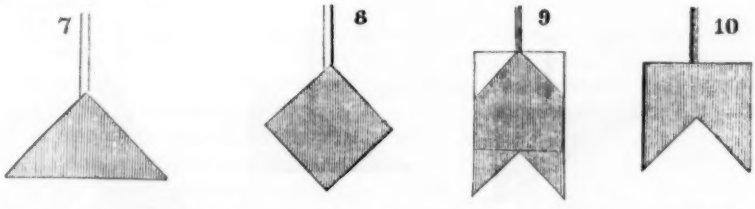


Fig. 9 were formed by removing the upper corners below, as in the figure. These seemed to have the advantage of fig. 8, but as light winds troubled us, we felt some hesitation in pronouncing them better. Four were superior to eight of No. 1. It was supposed that a slight accession of resistance to the lower ends, sweeping through the water, might be derived from opposing currents meeting in the forks, but we had no means to ascertain it, if it existed.

Fig. 10—cut out of plates eight inches square, with one-fourth, (minus a superficial inch,) removed, as shown in the figure. After several excursions, these were thought to exhibit a very slight advantage over fig. 3; but from subsequent tests, they seemed to be balanced. We, on another day, reversed them, as

Fig. 11, which had a decided preponderance over their competitors.—Six predominated slightly over the latter, and four were thought nearly equal to them. There was a difference of opinion on the last point—some thinking they were quite as effective as the opposing eight.

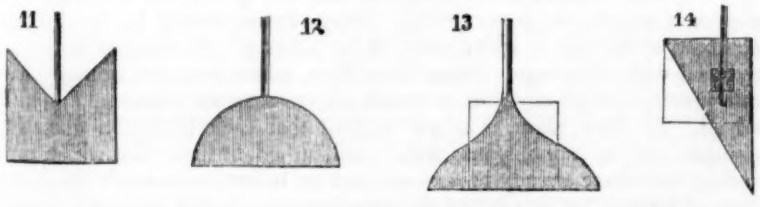


Fig. 12 was a semicircle. Mr. B. undertook to test these. They turned the boat in circles varying (from light winds and tides) from 30 to 150 feet. Four were thought sometimes equal, and sometimes superior, to eight of fig. 3. It is demonstrable that these blades are less effective, though in a

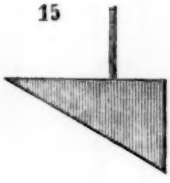
very small degree, than those marked fig. 7, and, when reversed, more powerful than fig. 4.

Fig. 13,—formed as in the figure, but not tried, as it was evident their value would be nearly that of fig. 7, probably a shade above them, but too minute to be detected, except in perfectly still water.

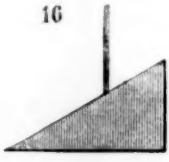
Fig. 14,—a right-angled triangle, 7 inches across the top, and ending in a point nearly 14 inches below it. These were, as might have been anticipated, more effective than those of fig. 3. "Everything about them," observed Mr. B., "shows their superiority." They, of course, entered the water without jarring.

The same were attached to the arms in the position of fig. 15, and were unable to compete with fig. 3. The latter had a slight advantage over them.

15



16



17

They were next reversed, as fig. 16, when they proved effective as figs. 7 and 12—four being equally so as the eight opposed to them.

They were finally changed to fig. 17, when the boat was turned so rapidly, as to make it difficult, with a wide oar, to keep her in one direction. Four were removed, and then she described a circle in less than 50 feet. Two more were taken away, leaving only a couple to act against the eight on the other wheel, and to which they proved equal.

From these experiments, it appears that, with equal areas, and equal dip, triangular blades may be rendered twice as effective as ordinary rectangular ones. This is made manifest by figs. 7, 12, and 16,—*four* of the former equalling eight of the latter. And this, too, while the propelling surface of the smaller number was only half that of the greater; for the four were as long in making a revolution, as were the eight. Hence, the speed of a boat may be increased by diminishing the number of her paddles—a fact still further elucidated by fig. 17.

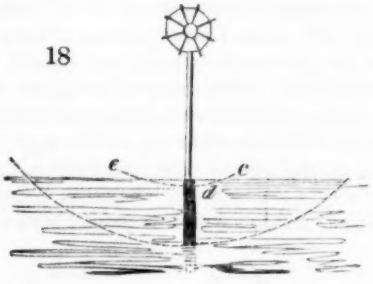
There can, I think, be little doubt, that the greater the velocity of a steamer's wheels, the fewer (within certain limits) should be the blades; and that, at the rate at which some of our boats go, the number might be reduced with advantage. Some have three, others four, and in more than one vessel, without any load on board, I have seen six submerged at each wheel. In these cases, is it not evident that each blade, on entering, plunges, not, as it ought, into water undisturbed, but into that which preceding ones have already broken up, and set in motion towards the stern? It would seem that one in the act of plunging, another sweeping under the shaft, and a third leaving the surface, are all that are necessary to be kept up; and that a greater number, as regards the speed of a boat, is positively injurious. Yet, under a vague idea of attaining a higher speed, the number of paddles has frequently been nearly doubled.

Snow, as every person knows, causes the wheels of land locomotives to slip upon, instead of rolling over, the rails. They revolve as usual, but their carriages make little progress; hence much of the power spent on them is expended to no purpose. So it is with paddle wheels. A boat never progresses in the ratio of their revolutions, because of the yielding medium in which, and against which, they act. They slip always—a result inevitable when massive solids wade through fluids. The distance between the Atlantic steamers' docks, in Liverpool and New York, has been calculated at 3023 miles, but their paddles, in each trip, pass over a space varying from 5000 to 8000 miles.* In steamers unaided by sails, the disproportion is often greater. Now can this be modified, by giving the paddles a better hold on the fluid they sweep through? The experiments figs. 5, 6, 7, 8, 9, 11, 12, 14, 16, and 17, furnish replies to the interrogatory.

The moral of the foregoing experiments is this:—As the propelling power of a paddle is greatest at its lower or outer extremity, and diminishes to nothing at the surface, so its face should enlarge with the dip, and be nothing, or next to nothing, above.—

Let *d*, fig. 18, represent the end of an ordinary blade, or paddle. Its upper part barely touches the water, and only for the moment it is in the position shown. But suppose it were immersed to the line *c*, *c*,—say four or five inches—it would even then be no sooner under, than above the surface again, so brief would be its immersion. The lower edge, in the meanwhile, would sweep along the extended curve there delineated.

18



Of what use, then, to make the upper part of a blade of equal extent with the lower? Why accumulate surface where it is of little avail, and withhold it from where it is most wanted?—expending materials and power without any adequate return, if not at an absolute loss. The quantity of water carried over a wheel, is certainly greater by ordinary, than it would be by triangular, paddles. The popular form and position of paddles are unphilosophical, if viewed simply as propellers. Embrace the same area in any other outline—in a circle, ellipse, square, pentagon, hexagon, octa-

* The English steamer *Europa* came in on the 25th ult., after the remarkably short trip of eleven days. Her wheels are 32 feet in diameter, and taking their revolutions at the average of 17 per minute, her paddles swept over a space exceeding 5000 miles. The steam ship *Northerner* has wheels 31 feet diameter. In running from New York to Charleston, 630 miles, they made 52,000 revolutions, in another trip, 51,000. The *Cherokee's* wheels are the same dimensions. In her first trip, to Savannah, a distance of 700 miles, they made 53,000 revolutions. The practice now is, to lessen the slip of marine carriage wheels, and make them approach nearer in effect to those used on land, by increasing their width: that is, the length of their paddles. Hence those of the *Atlantic*, one of the large Liverpool Liners now building, are to be 12½ feet long; but for the difficulty of entering the English Docks, they would have been 14 feet. Those of the *Hermann* and *Washington*, of the Bremen Line, are respectively 8 feet and 7½; while the *Franklin*, preparing for the same line, has them 12 feet. The English mail boats of recent build, the *Europa* and her three associates, have paddles between 8 and 9 feet.

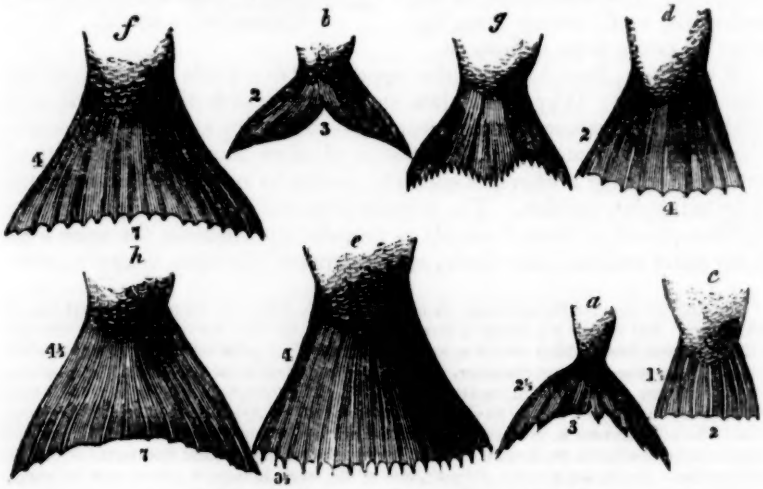
gon, or other polygonous figure, and the propelling properties would be increased, and the jar arising from their striking the water, also diminished.

If the long paralellogram be preferred, because of the ready application of wooden planks, then is the principal sacrificed to an accessory—the greater to the less. If triangular, or other improved blades, require the adoption of plates of metal, would it be wise to reject them on that account? But of this by and bye. We shall see that thick wooden blades ought to be condemned on account of defects inherent in them.

But what is this expansion of the lower part of a paddle, and contraction above, but Nature's own plan? In the tails and fins of fishes, in wings of birds and insects, and especially in the palmipeds, she has nowhere sanctioned a rectangular propeller. All are inclined to equilateral, scalenous, or isosceletic triangles, or are made up of them. Nor does she ever unite the levers that work them to their sides. The junction is invariably at an angle, and the reason is apparent—that the largest surface may have the longest sweep.

With this view, the bodies of fishes taper down to meet the blades; retaining only sufficient muscle to work them. The other day, I had an opportunity of sketching the following. I am ashamed to acknowledge that, till then, I was ignorant of the exact forms of these natural propellers, although most of them had passed under my observation on a thousand occasions. Too many of us spend no more thought on the infinitely curious and instructive mechanisms submitted by the Creator to our inspection daily, than does the ox on the vegetable glories he feeds on. The sentiment applies not more to religious, than to physical truths. "Light shineth in darkness, and the darkness comprehendeth it not." We grope, as if blind, for that which is patent before us.

Fig. 19.



a—Mackerel. *e*—Cod.
b—Porgy. *f*—Striped Bass.
c—Flounder. *g*—Sea Bass.
d—Black Fish. *h*—Salmon.

The general outlines and proportions are given in the preceding figures;

the dimensions, of course, vary with the age and growth of individuals. The figures denote the width and length of the expanded tails—the latter being taken from the termination of the body, as shown by the curves, which reach more or less into the tails: i. e. to strengthen them where strength is most required.

I confess I had no idea of meeting with figures so closely allied to the artificial ones which I had found most effectual as propellers. With the exception of the first two, the whole approach to equilateral triangles.

In the absence of a more extended acquaintance with the minuter aqueous and sub-aqueous organisms, the nearest of natural analogues to steam vessels, seem to be the principal swimming-birds. These glide through two elements at once. Their long and heavy bodies, adapted to float gracefully on water, are provided with organs of propulsion, placed far behind their common centres of gravity—the cause that makes them such awkward travelers on land. When a gale blows in the direction they wish to pursue, like human navigators, they take advantage of it; they spread their wings to catch it, and are driven onward then, as steamers are, by both wind and paddles.

The reciprocating action, and the expanding and collapsing features of their aqueous organs of progression, are supposed to be unsuited to the magnitude, materials, and velocity, of artificial ones. Perhaps they are; but may not their contour be perfectly applicable; since, when open, and in action, the circumstances of the two bodies propelled—the bird and the boat—are not essentially dissimilar? Now, there is a marked adhesion to the triangular form in the webbed feet of birds; showing that, in the judgment of the Creator, such an outline is the best for the purposes of their propulsion. Nor does it appear that this outline has, in any material way, been modified to meet other exigencies. In the feet of water-fowl it is almost identical with the tail of the sea bass. The legs, or rods, that wield these ornithologic paddles, are invariably united to them at their points, or angles, and clearly for the reason already stated.

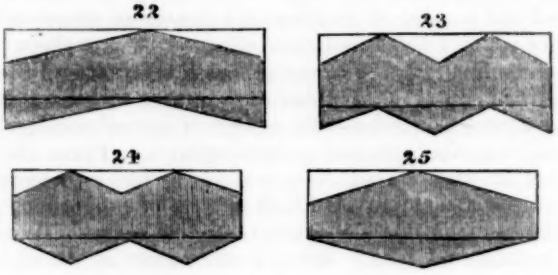
20

Fig. 20 represents the foot of a petrel. It is a type of all the swimming birds' propellers. Few, except professional naturalists, could distinguish between it and the same organ in geese, ducks, gulls, swans, the albatross, cormorant, diver, flamingo, &c., &c. Although natural paddles are submerged when at work, and those of our wheels emerge into air, to repeat their strokes, I doubt if a more efficient form could be given to the latter than the above. The cuspated extremity would obviate the jar consequent on straight-edged blades striking the water.

If I had a new boat to fit propellers to, they should resemble figs. 7, 6, or 17; or I would rather make them like half the foot of a swimming-bird, as fig. 21, in the margin,—the perpendicular sides being next the vessel, that the greatest strain might be nearest to the power. Such blades would not be raised out of the sea by a vessel's rolling, nor, when submerged, be subject to excessive strainings, as common ones are. They would produce no concussion, or but little, on dipping, and would be twice as effective as the same area employed in the current form and fashion.

21

If the principle were required to be adopted in the present paddles, it could be done at a trifling cost. I would remove portions from the upper sides, and attach them below, somewhat after the manner shown at figs. 22, 23, 24, and 25.



The portions *might* be removed by curved instead of straight lines.

If I used blades similar to fig. 7, I would vandyke their lower edges as at 23, point them as at 25, or fork them as at 22.

(To be Continued.)

TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Account of the Experiments to determine the Principal Laws and Numerical Data, which enter into the Calculations of Steam Engines. By M. V. REGNAULT.

EIGHTH MEMOIR.

On the Elastic Force of Steam at Different Temperatures.

(Continued from Vol. XVI. page 398.)

PART THIRD.—*Graphic Construction of the Experiments, and Calculation of the Formulæ of Interpolation.*

After explaining fully the curves which represent the results of his experiments, M. Regnault proceeds to discuss the formulæ of interpolation, by which the temperatures of steam may be calculated from the elastic force, and *vice versa.*

After noticing the formulæ proposed by Prony, *(Journal de l'Ecole Polytechnique, 2e cahier, p. 1,)* by Dr. Young, *(Nat. Philos., vol. II., p. 400,)* by Creighton, *(Philos. Mag., vol. LIII., p. 266,)* Southern, *(Robison's Mechan. Philos., vol. II., p. 172,)* Tredgold, *(Treatise on the Steam Engine, p. 57,)* Coriolis, *(Du calcul des effets des Machines, 1829, p. 58,)* Arago and Dulong, *(Memoires de l'Institut, tom. X. p. 230,* and *Ann. de Chim. et de Phys., 2e serie, tom. XLIII., p. 74,)* by M. Roche, and by M. Biot, *(Connaissance des Temps., 1844,)* and remarking that of these, that of M. Roche was arrived at by mathematical deduction from the general principles of the theory of vapors, and although the reasoning was objected to by MM. Dulong and Arago, *(Mem. de l'Institut., tom. X. p. 227,)* had

been again got by other philosophers, from similar premises—as by M. Clapeyron, *(Journal de l'Ecole Polytechnique, tome* XIV., *p.* 153,*)* August, *(Annales de Poggendorff, tom.* XIII., *p.* 122, and *tom.* LVIII., *p.* 334,*)* Von Wrede, *(Ann. de Poggendorff, tom.* LIII., *p.* 225,*)* and by Holtzmann, *(Ann. de Poggendorff, Ergänzungsheft, tom.* II., *p.* 183.*)* After noticing at length all these formulæ, and comparing them with his experiments, he finally proposes two of the form proposed by M. Biot, the first of which applies to the temperatures of the air, and the latter to those of the mercurial thermometer, and he shews that they present, throughout the whole series, the most satisfactory accordance with the experiments.

Thus for the first formula, designated by M. Regnault as formula (H), which is

$$log.\ F = a - b\alpha_1^{\ x} - c\varsigma_1^{\ x}$$

in which F=the elastic force $x = T + 20°$, T being the number of centigrade degrees above the temperature of melting ice; and the constants are as follows:

$$log.\ \alpha_1 = \bar{1}\cdot 994049292.$$
$$log.\ \varsigma_1 = \bar{1}\cdot 998343862.$$
$$log.\ b = 0\cdot 1397743.$$
$$log.\ c = 0\cdot 6924351.$$
$$a = 6\cdot 2640348.$$

The five temperatures selected for the calculation were $-20° + 40°$, 100°, 160°, 220°. Between the first two temperatures, the formula gives the elastic forces smaller than measurements upon the curve, but the greatest difference is only 0·12 mm.; and it would be easy to get rid of all these little differences, by increasing, by 3 or 4 centimetres, (a quantity scarcely appreciable in the observations,) the value assigned to the tension of the vapor at —20°. This would make the coincidence between the curve and the formula between —20° and $+40°$ complete.

Between the fixed points 40° and 100°, the accordance between the curve and the formula is absolute.

From 100° to 160°, the elastic forces calculated by the formula are a little greater than those given by the curve; but the differences are extremely small, scarcely rising to 5 or 6 millimetres, a quantity corresponding to a difference of $\frac{1}{20}$th of a degree of temperature.

Between 160° and 200°, the formula gives still values greater than the curve; but these differences are so small, that it is impossible to answer for the observations within their limits; for the greatest difference which presents itself at the temperature of 200°, is 29 millimetres, and corresponds to a difference of about $\frac{1}{10}$th of a degree.

The second formula, (I), which is intended to represent the results when the indications of the mercurial thermometer are used, is of the same form.

$$log.\ F = a - b\alpha_1^{\ x} - c\varsigma_1^{\ x} \qquad \text{where } x = T + 20° \text{ as before.}$$

The constants now are $log.\ \alpha_1 = \bar{1}\cdot 994995207.$

$$log.\ \varsigma_1 = \bar{1}\cdot 998705255.$$
$$log.\ b = 0\cdot 3176016.$$
$$log.\ c = 0\cdot 6569893.$$
$$a = 6\cdot 5761352.$$

This formula, when compared with the curve, shews an equal degree of accordance with the results.

M. Regnault, however, remarks that it is not safe to use these formulæ for the calculation of tensions much above the highest used as a fixed point in their determination, which was 28 atmospheres,—the greatest pressure to which his experiments extended. This extension could only be safely made, if the formula of interpolation represented the true physical law of the phenomenon. It is frequently observed that two formulæ of interpolation, which present very small differences within the limits of their experimental data, diverge promptly from each other, beyond these limits. Thus the formulæ (H) and (K), which accord very satisfactorily between the two limits —20° and +220°, which are the extreme temperatures employed in calculating the constants, present already a difference of 38 millimetres for a temperature of 230°, and 173 millimetres at a temperature of 250°.

This part of the memoir concludes in the following words:

"It remains only for me now to compare the results of my experiments with those obtained by the physical philosophers who have previously studied the same question. This comparison is easy for temperatures between 0° and 100°, because there can be but little uncertainty as to the movements of the thermometers within these limits. I have been able to determine that the observations of M. Magnus, which were published nearly at the same time as mine, and embrace an interval of temperature from —6° to +105°, accord very well with mine; but the comparison of my results with those of MM. Arago and Dulong, or with those of the American Committee, present much more uncertainty. The philosophers who performed these experiments, observed their temperatures only upon mercurial thermometers, and in order that the comparison should be possible, it would be necessary to admit that their thermometers accorded with mine. This hypothesis is very unlikely; my mercurial thermometers were made of the crystal of Choisy-le-Roy; it is very probable that the instruments of MM. Arago and Dulong had reservoirs of common glass. We can have no precise notion of the nature of the thermometer used by the American philosophers, but I think that the method by which they determined the fixed points of their instruments, also contributed to prevent their thermometer from being comparable with ours."

"However this may be, admitting the infinitely improbable hypothesis that all our instruments are rigorously comparable, I find that the observations of MM. Arago and Dulong differ but little from mine at high temperatures; while those of the American Committee differ much more. The differences are even too large to be attributed to errors of observation. I do not doubt that they ought to be attributed to the circumstance that their mercurial thermometer moved very differently from mine."

The memoir terminates with three tables of the elastic forces of water, which will be found useful in various cases.

The first is a general table of the elastic forces of steam, for each degree centigrade of the air thermometer, from the temperature —32° (—25·6° F.) to +230° (446° F.) These forces between —32° and 0°, were calculated by the formula (E). From 0° to 100°, the formula (D); and from 100° to 230°, the formula (H) were used. The whole table might have been

calculated throughout its whole extent by the formula (H), and the results above 40° would have been identical; but at lower temperatures, the elastic forces given by (H) would have been rather too small.

The second table includes the elastic forces of the vapor of water, for each tenth of a degree centigrade, from —10° to +35°, (14° to 95° F.) This table is principally useful in meteorology. Between —10° and 0°, the numbers of this table differ a little from those of the preceding table; this is occasioned by the two tables, which were formed at different epochs, having been calculated by different formulæ; but the differences are insignificant, for they scarcely rise to two-tenths of a millimetre.

Finally, the third table includes the elastic forces of the vapor of water, for every tenth of a degree between 85° and 101°, (185° to 213·8° F.) This table is designed for hypsometric observations, in which the heights of the barometer are calculated by the observed temperature of the boiling of water.

We give with these three tables, the formulæ (D), (E), and (H), by which they were calculated.

FORMULA (E).

$F = a + ba^x$ $\quad x = t + 32°$ $\quad t$ = temp. centigrade.

$log.\ b = \bar{1}\cdot6024724$

$log.\ a_1 = 0\cdot0333980$

$a = -0\cdot08038.$

FORMULA (D).

$log.\ F = a + ba^t - cc_1^t$ $\quad t$ = temp. in centigrade degrees above 0°.

$log.\ a_1 = 0\cdot006865036$

$log.\ c_1 = \bar{1}\cdot9967249$

$log.\ b = \bar{2}\cdot1340339$

$log.\ c = 0\cdot6116485$

$a = 4\cdot7384380.$

FORMULA (H).

$F = a - ba_1^x - cc_1^x$ $\quad x = T + 20°.$ $\quad T$ = centig. deg. from 0°.

$log.\ a_1 = \bar{1}\cdot994049292$

$log.\ c_1 = \bar{1}\cdot998343862$

$log.\ b = 0\cdot1397743$

$log.\ c = 0\cdot6924351$

$a = 6\cdot2640348.$

In all these formulæ, F represents the elastic force of the vapor, expressed in millimetres.

TABLE I.

Table of the Elastic Forces of the Vapor of Water, from —32° *to* +230° *Centigrade; in millimetres.*

Temperatures	Elastic Forces.	Differences for 1°.	Temperatures.	Elastic Forces.	Differences for 1°.	Temperatures	Elastic Forces	Differences for 1°.
°	mm	mm.	°	mm.	mm.	°	mm.	mm
—32	0·320	0·032	19	16·346	1·045	70	233·093	10·300
31	0·352	0·034	20	17·391	1·104	71	243·393	10·680
30	0·386	0·038	21	18·495	1·164	72	254·073	11·074
29	0·424	0·040	22	19·659	1·229	73	265·147	11·477
28	0·464	0·044	23	20·888	1·296	74	276·624	11·893
27	0·508	0·047	24	22·184	1·366	75	288·517	12·321
26	0·555	0·050	25	23·550	1·438	76	300·838	12·762
25	0·605	0·055	26	24·988	1·517	77	313·600	13·211
24	0·660	0·059	27	25·505	1·596	78	326·811	13·677
23	0·719	0·064	28	28·101	1·681	79	340·488	14·155
22	0·783	0·070	29	29·782	1·766	80	354·643	14·644
21	0·853	0·074	30	31·548	1·858	81	369·287	15·148
20	0·927	0·081	31	33·406	1·953	82	384·435	15·666
19	1·008	0·087	32	35·359	2·052	83	400·101	16·197
18	1·095	0·094	33	37·411	2·154	84	416·298	16·743
17	1·189	0·101	34	39·565	2·262	85	433·041	17·303
16	1·290	0·110	35	41·827	2·374	86	450·344	17·877
15	1·400	0·118	36	44·201	2·490	87	468·221	18·466
14	1·518	0·128	37	46·691	2·611	88	486·687	19·072
13	1·646	0·137	38	49·302	2·737	89	505·759	19·691
12	1·783	0·150	39	52·039	2·867	90	525·450	20·328
11	1·933	0·160	40	54·906	3·004	91	545·778	20·979
10	2·093	0·174	41	57·910	3·145	92	566·757	21·649
9	2·267	0·188	42	61·055	3·291	93	588·406	22·334
8	2·455	0·203	43	64·346	3·444	94	610·740	23·038
7	2·658	0·218	44	67·790	3·601	95	633·778	23·757
6	2·876	0·237	45	71·391	3·767	96	657·535	24·494
5	3·113	0·245	46	75·158	3·935	97	682·029	25·251
4	3·368	0·276	47	79·093	4·111	98	707·280	26·025
3	3·644	0·297	48	83·204	4·295	99	733·305	26·695
2	3·941	0·322	49	87·499	4·483	100	760·000	27·590
1	4·263	0·337	50	91·982	4·679	101	787·590	28·420
0	4·600	0·340	51	96·661	4·882	102	816·010	29·270
+1	4·940	0·362	52	101·543	5·093	103	845·280	30·130
2	5·302	0·385	53	106·636	5·309	104	875·410	31·000
3	5·687	0·410	54	111·945	5·533	105	906·410	31·910
4	6·097	0·437	55	117·478	5·766	106	938·310	32·830
5	6·534	0·464	56	123·244	6·007	107	971·140	33·770
6	6·998	0·494	57	129·251	6·254	108	1004·910	34·740
7	7·492	0·525	58	135·505	6·510	109	1039·650	35·720
8	8·017	0·557	59	142·015	6·776	110	1075·370	36·820
9	8·574	0·591	60	148·791	7·048	111	1112·090	37·740
10	9·165	0·627	61	155·839	7·331	112	1149·830	38·780
11	9·792	0·665	62	163·170	7·621	113	1188·610	39·860
12	10·457	0·705	63	170·791	7·923	114	1228·470	40·940
13	11·162	0·746	64	178·714	8·231	115	1269·410	42·060
14	11·908	0·791	65	186·945	8·551	116	1311·470	43·190
15	12·699	0·837	66	195·496	8·880	117	1354·660	44·340
16	13·536	0·885	67	204·376	9·220	118	1399·020	45·530
17	14·421	0·936	68	213·596	9·569	119	1444·550	46·730
18	15·357	0·989	69	223·165	9·928	120	1491·280	47·970
19	16·346		70	233·093		121	1539·250	

TABLE I.—CONTINUED.

Temperatures	Elastic Forces	Differences for 1°.	Temperatures	Elastic Forces	Differences for 1°.	Temperatures	Elastic Forces.	Differences for 1°.
°	mm.	mm.	°	mm	mm.	°	mm.	mm.
+121	1539·250	49·220	158	4419·450	114·910	195	10519·630	226·320
122	1588·470	50·490	159	4534·360	117·260	196	10745·950	230·050
123	1638·960	51·800	160	4651·620	119·660	197	10975·000	233·820
124	1690·760	53·120	161	4771·280	122·080	198	11209·820	237·640
125	1743·880	54·470	162	4893·360	124·550	199	11447·460	241·500
126	1798·350	55·850	163	5017·910	127·060	200	11688·960	245·410
127	1854·200	57·270	164	5144·970	129·570	201	11934·370	249·320
128	1911·470	58·680	165	5274·540	132·150	202	12183·690	253·310
129	1970·150	60·130	166	5406·690	134·740	203	12437·000	257·300
130	2030·280	61·660	167	5541·430	137·390	204	12694·300	261·360
131	2091·940	63·090	168	5678·820	140·080	205	12955·660	265·460
132	2155·030	64·660	169	5818·900	142·760	206	13221·120	269·630
133	2219·690	66·230	170	5961·660	145·530	207	13490·750	273·780
134	2285·920	67·810	171	6107·190	148·290	208	13764·530	277·990
135	2353·730	69·430	172	6255·480	151·120	209	14042·520	282·280
136	2423·160	71·070	173	6406·600	153·950	210	14324·800	286·520
137	2494·230	72·770	174	6560·550	156·850	211	14611·320	290·900
138	2567·000	74·440	175	6717·430	159·790	212	14902·220	295·260
139	2641·440	76·190	176	6877·220	162·750	213	15197·480	299·690
140	2717·630	77·940	177	7039·970	165·750	214	15497·170	304·160
141	2795·570	79·730	178	7205·720	168·800	215	15801·330	308·610
142	2875·300	81·560	179	7374·520	171·870	216	16109·940	313·210
143	2956·860	83·400	180	7546·390	174·980	217	16423·150	317·750
144	3040·260	85·290	181	7721·370	178·150	218	16740·900	322·390
145	3125·550	87·190	182	7899·520	181·320	219	17063·290	327·070
146	3212·740	89·130	183	8080·840	184·560	220	17390·360	331·770
147	3301·870	91·110	184	8265·400	187·830	221	17722·130	336·550
148	3392·980	93·110	185	8453·230	191·120	222	18058·640	341·300
149	3486·090	95·140	186	8644·350	194·470	223	18399·940	346·130
150	3581·230	97·200	187	8838·820	197·860	224	18746·070	350·970
151	3678·430	99·310	188	9036·680	201·270	225	19097·040	355·880
152	3777·740	101·440	189	9237·950	204·750	226	19452·920	360·840
153	3879·180	103·590	190	9442·700	208·230	227	19813·760	365·850
154	3982·770	105·790	191	9650·930	211·780	228	20179·610	370·870
155	4088·560	108·030	192	9862·710	215·330	229	20550·480	375·920
156	4196·590	110·290	193	10078·040	218·970	230	20926·400	
157	4306·880	112·570	194	10297·010	222·620			
158	4419·450		195	10519·630				

TABLE II.

Table of the Elastic Forces of the Vapor of Water, for every tenth of a degree, from —10° to +35° centigrade; in millimetres.

Temperatures.	Tension	Differences for 0·1°.	Temperatures.	Tension	Differences for 0·1°.	Temperatures.	Tension.	Differences for 0·1°.
°	mm	mm.	°	mm.	mm.	°	mm.	mm.
—10·0	2·078							
		0·018						
9·9	2·096		—5·9	2·914		—1·9	3·985	
		0·018			0·024			0·031
9·8	2·114		5·8	2·938		1·8	4·016	
		0·018			0·024			0·031
9·7	2·132		5·7	2·962		1·7	4·047	
		0·018			0·024			0·031
9·6	2·150		5·6	2·986		1·6	4·078	
		0·018			0·024			0·031
9·5	2·168		5·5	3·010		1·5	4·109	
		0·018			0·024			0·031
9·4	2·186		5·4	3·034		1·4	4·140	
		0·018			0·024			0·031
9·3	2·204		5·3	3·058		1·3	4·171	
		0·019			0·024			0·032
9·2	2·223		5·2	3·082		1·2	4·203	
		0·019			0·024			0·032
9·1	2·242		5·1	3·106		1·1	4·235	
		0·019			0·025			0·032
9·0	2·261		5·0	3·131		1·0	4·267	
		0·019			0·025			0·032
8·9	2·280		4·9	3·156		0·9	4·299	
		0·019			0·025			0·032
8·8	2·299		4·8	3·181		0·8	4·331	
		0·019			0·025			0·033
8·7	2·318		4·7	3·206		0·7	4·364	
		0·019			0·025			0·033
8·6	2·337		4·6	3·231		0·6	4·397	
		0·019			0·026			0·033
8·5	2·356		4·5	3·257		0·5	4·430	
		0·020			0·026			0·033
8·4	2·376		4·4	3·283		0·4	4·463	
		0·020			0·026			0·034
8·3	2·396		4·3	3·309		0·3	4·497	
		0·020			0·026			0·034
8·2	2·416		4·2	3·335		0·2	4·531	
		0·020			0·026			0·034
8·1	2·436		4·1	3·361		0·1	4·565	
		0·020			0·026			0·035
8·0	2·456		4·0	3·387		0·0	4·600	
		0·021			0·027			0·035
7·9	2·477		3·9	3·414		0·0	4·600	
		0·021			0·027			0·033
7·8	2·498		3·8	3·441		+0·1	4·633	
		0·021			0·027			0·033
7·7	2·519		3·7	3·468		0·2	4·667	
		0·021			0·027			0·033
7·6	2·540		3·6	3·495		0·3	4·700	
		0·021			0·027			0·033
7·5	2·561		3·5	3·522		0·4	4·733	
		0·021			0·028			0·033
7·4	2·582		3·4	3·550		0·5	4·767	
		0·021			0·028			0·034
7·3	2·603		3·3	3·578		0·6	4·801	
		0·021			0·028			0·034
7·2	2·624		3·2	3·606		0·7	4·836	
		0·021			0·028			0·034
7·1	2·645		3·1	3·634		0·8	4·871	
		0·021			0·028			0·034
7·0	2·666		3·0	3·662		0·9	4·905	
		0·022			0·029			0·034
6·9	2·688		2·9	3·691		1·0	4·940	
		0·022			0·029			0·035
6·8	2·710		2·8	3·720		1·1	4·975	
		0·022			0·029			0·035
6·7	2·732		2·7	3·749		1·2	5·011	
		0·022			0·029			0·035
6·6	2·754		2·6	3·778		1·3	5·047	
		0·022			0·029			0·035
6·5	2·776		2·5	3·807		1·4	5·082	
		0·022			0·029			0·035
6·4	2·798		2·4	3·836		1·5	5·118	
		0·023			0·029			0·037
6·3	2·821		2·3	3·865		1·6	5·155	
		0·023			0·030			0·037
6·2	2·844		2·2	3·895		1·7	5·191	
		0·023			0·030			0·037
6·1	2·867		2·1	3·925		1·8	5·228	
		0·023			0·030			0·037
6·0	2·890		2·0	3·955		1·9	5·265	
		0·024			0·030			0·037

TABLE II.—CONTINUED.

Temperatures.	Tension	Differences for 0·1°.	Temperatures	Tension.	Differences for 0·1°.	Temperatures.	Tension.	Differences for 0·1°
°	mm	mm	°	mm.	mm.	°	mm.	mm.
+2·0	5·302	0·038	+7·0	7·492	0·052	+12·0	10·457	0·069
2·1	5·340	0·038	7·1	7·544	0·052	12·1	10·526	0·069
2·2	5·378	0·038	7·2	7·595	0·052	12·2	10·596	0·069
2·3	5·416	0·038	7·3	7·647	0·052	12·3	10·665	0·069
2·4	5·454	0·038	7·4	7·699	0·052	12·4	10·734	0·069
2·5	5·491	0·039	7·5	7·751	0·053	12·5	10·804	0·071
2·6	5·530	0·039	7·6	7·804	0·053	12·6	10·875	0·071
2·7	5·569	0·039	7·7	7·857	0·053	12·7	10·947	0·071
2·8	5·608	0·039	7·8	7·910	0·053	12·8	11·019	0·071
2·9	5·647	0·039	7·9	7·964	0·053	12·9	11·090	0·071
3·0	5·687	0·040	8·0	8·017	0·055	13·0	11·062	0·073
3·1	5·727	0·040	8·1	8·072	0·055	13·1	11·235	0·073
3·2	5·767	0·040	8·2	8·126	0·055	13·2	11·309	0·073
3·3	5·807	0·040	8·3	8·181	0·055	13·3	11·383	0·073
3·4	5·848	0·040	8·4	8·236	0·055	13·4	11·456	0·073
3·5	5·889	0·041	8·5	8·291	0·056	13·5	11·530	0·075
3·6	5·930	0·041	8·6	8·347	0·056	13·6	11·605	0·075
3·7	5·972	0·041	8·7	8·404	0·056	13·7	11·681	0·075
3·8	6·014	0·041	8·8	8·461	0·056	13·8	11·757	0·075
3·9	6·055	0·041	8·9	8·517	0·056	13·9	11·832	0·075
4·0	6·097	0·043	9·0	8·574	0·058	14·0	11·906	0·078
4·1	6·140	0·043	9·1	8·632	0·058	14·1	11·988	0·078
4·2	6·183	0·043	9·2	8·690	0·058	14·2	12·064	0·078
4·3	6·226	0·043	9·3	8·748	0·058	14·3	12·142	0·078
4·4	6·270	0·043	9·4	8·807	0·058	14·4	12·220	0·078
4·5	6·313	0·044	9·5	8·865	0·060	14·5	12·298	0·080
4·6	6·357	0·044	9·6	8·925	0·060	14·6	12·278	0·080
4·7	6·401	0·044	9·7	8·985	0·060	14·7	12·458	0·080
4·8	6·445	0·044	9·8	9·045	0·060	14·8	12·538	0·080
4·9	6·490	0·044	9·9	9·105	0·060	14·9	12·619	0·080
5·0	6·534	0·046	10·0	9·165	0·062	15·0	12·699	0·082
5·1	6·580	0·046	10·1	9·227	0·062	15·1	12·781	0·082
5·2	6·625	0·046	10·2	9·288	0·062	15·2	12·864	0·082
5·3	6·671	0·046	10·3	9·350	0·062	15·3	12·947	0·082
5·4	6·717	0·046	10·4	9·412	0·062	15·4	13·029	0·082
5·5	6·763	0·047	10·5	9·474	0·063	15·5	13·112	0·085
5·6	6·810	0·047	10·6	9·537	0·063	15·6	13·197	0·085
5·7	6·857	0·047	10·7	9·601	0·063	15·7	13·281	0·085
5·8	6·904	0·047	10·8	9·665	0·063	15·8	13·366	0·085
5·9	6·951	0·047	10·9	9·728	0·063	15·9	13·451	0·085
6·0	6·998	0·049	11·0	9·792	0·065	16·0	13·536	0·087
6·1	7·047	0·049	11·1	9·857	0·065	16·1	13·623	0·087
6·2	7·095	0·049	11·2	9·923	0·065	16·2	13·710	0·087
6·3	7·144	0·049	11·3	9·989	0·065	16·3	13·797	0·087
6·4	7·193	0·049	11·4	10·054	0·065	16·4	13·885	0·087
6·5	7·242	0·050	11·5	10·120	0·067	16·5	13·982	0·090
6·6	7·292	0·050	11·6	10·187	0·067	16·6	14·062	0·090
6·7	7·342	0·050	11·7	10·255	0·067	16·7	14·151	0·090
6·8	7·392	0·050	11·8	10·322	0·067	16·8	14·241	0·090
6·9	7·443	0·050	11·9	10·389	0·067	16·9	14·331	0·090

TABLE II.—CONTINUED.

Temperatures.	Tension.	Differences for 0·1°.	Temperatures	Tension.	Differences for 0·1°.	Temperatures	Tension.	Differences for 0·1°.
°	mm.	mm.	°	mm.	mm.	°	mm.	mm.
+17·0	14·421	0·092	+22·0	19·659	0·121	+27·0	26·505	0·158
17·1	14·513	0·092	22·1	19·780	0·121	27·1	26·663	0·158
17·2	14·605	0·092	22·2	19·901	0·121	27·2	26·820	0·158
17·3	14·697	0·092	22·3	20·022	0·121	27·3	26·978	0·158
17·4	14·790	0·092	22·4	20·143	0·121	27·4	27·136	0·158
17·5	14·882	0·095	22·5	20·265	0·125	27·5	27·294	0·161
17·6	14·977	0·095	22·6	20·389	0·125	27·6	27·455	0·161
17·7	15·072	0·095	22·7	20·514	0·125	27·7	27·617	0·161
17·8	15·167	0·095	22·8	20·639	0·125	27·8	27·778	0·161
17·9	15·262	0·095	22·9	20·763	0·125	27·9	27·939	0·161
18·0	15·357	0·097	23·0	20·888	0·128	28·0	28·101	0·166
18·1	15·454	0·097	23·1	21·016	0·128	28·1	28·267	0·166
18·2	15·552	0·097	23·2	21·144	0·128	28·2	28·433	0·166
18·3	15·650	0·097	23·3	21·272	0·128	28·3	28·599	0·166
18·4	15·747	0·097	23·4	21·400	0·128	28·4	28·765	0·166
18·5	15·845	0·100	23·5	21·528	0·131	28·5	28·931	0·170
18·6	15·945	0·100	23·6	21·659	0·131	28·6	29·101	0·170
18·7	16·045	0·100	23·7	21·790	0·131	28·7	29·271	0·170
18·8	16·145	0·100	23·8	21·921	0·131	28·8	29·441	0·170
18·9	16·246	0·100	23·9	22·053	0·131	28·9	29·612	0·170
19·0	16·346	0·103	24·0	22·184	0·135	29·0	29·782	0·174
19·1	16·449	0·103	24·1	22·319	0·135	29·1	29·956	0·174
19·2	16·552	0·103	24·2	22·453	0·135	29·2	30·131	0·174
19·3	16·655	0·103	24·3	22·588	0·135	29·3	30·305	0·174
19·4	16·758	0·103	24·4	22·723	0·135	29·4	30·479	0·174
19·5	16·861	0·106	24·5	22·858	0·138	29·5	30·654	0·179
19·6	16·967	0·106	24·6	22·996	0·138	29·6	30·833	0·179
19·7	17·073	0·106	24·7	23·135	0·138	29·7	31·011	0·179
19·8	17·179	0·106	24·8	23·273	0·138	29·8	31·190	0·179
19·9	17·285	0·106	24·9	23·411	0·138	29·9	31·369	0·179
20·0	17·391	0·109	25·0	23·550	0·142	30·0	31·548	0·181
20·1	17·500	0·109	25·1	23·692	0·142	30·1	31·729	0·182
20·2	17·608	0·109	25·2	23·834	0·142	30·2	31·911	0·183
20·3	17·717	0·109	25·3	23·976	0·142	30·3	32·194	0·184
20·4	17·826	0·109	25·4	24·119	0·142	30·4	32·278	0·185
20·5	17·935	0·112	25·5	24·261	0·145	30·5	32·463	0·187
20·6	18·047	0·112	25·6	24·406	0·145	30·6	32·650	0·187
20·7	18·159	0·112	25·7	24·552	0·145	30·7	32·837	0·189
20·8	18·271	0·112	25·8	24·697	0·145	30·8	33·026	0·189
20·9	18·383	0·112	25·9	24·842	0·145	30·9	33·215	0·189
21·0	18·495	0·115	26·0	24·988	0·150	31·0	33·205	0·190
21·1	18·610	0·115	26·1	25·138	0·150	31·1	33·596	0·191
21·2	18·724	0·115	26·2	25·288	0·150	31·2	33·787	0·191
21·3	18·839	0·115	26·3	25·438	0·150	31·3	33·980	0·193
21·4	18·954	0·115	26·4	25·588	0·150	31·4	34·174	0·194
21·5	19·069	0·118	26·5	25·738	0·153	31·5	34·368	0·194
21·6	19·187	0·118	26·6	25·891	0·153	31·6	34·564	0·196
21·7	19·305	0·118	26·7	26·045	0·153	31·7	34·761	0·197
21·8	19·423	0·118	26·8	26·198	0·153	31·8	34·959	0·198
21·9	19·541	0·118	26·9	26·351	0·153	31·9	35·159	0·200

TABLE II.—CONTINUED.

Temperatures.	Tension.	Differences for 0·1°.	Temperatures.	Tension.	Differences for 0·1°.	Temperatures.	Tension.	Differences for 0·1°.
°	mm.	mm.	°	mm.	mm.	°	mm.	mm.
+32·0	35·359	0·200	+33·0	37·410	0·211	+34·0	39·565	0·221
32·1	35·559	0·200	33·1	37·621	0·211	34·1	39·786	0·221
32·2	35·760	0·201	33·2	37·832	0·213	34·2	40·007	0·223
32·3	35·962	0·202	33·3	38·045	0·213	34·3	40·230	0·225
32·4	36·165	0·203	33·4	38·258	0·215	34·4	40·455	0·225
32·5	36·370	0·205	33·5	38·473	0·216	34·5	40·680	0·227
32·6	36·576	0·206	33·6	38·689	0·217	34·6	40·907	0·228
32·7	36·783	0·207	33·7	38·906	0·218	34·7	41·135	0·229
32·8	36·991	0·208	33·8	39·124	0·220	34·8	41·364	0·231
32·9	37·200	0·209	33·9	39·344	0·221	34·9	41·595	0·232
						35·0	41·827	

TABLE III.

Table of the Tensions of the Vapor of Water, for every tenth of a degree, from 85° to 101° Centigrade; in millimetres.

85·0	433·04	1·71	88·5	496·15	1·91	92·0	566·76	2·13
85·1	434·75	1·71	88·6	498·06	1·91	92·1	568·89	2·13
85·2	435·46	1·71	88·7	499·98	1·92	92·2	571·03	2·14
85·3	438·17	1·72	88·8	501·90	1·92	92·3	573·18	2·15
85·4	439·89	1·73	88·9	503·82	1·92	92·4	575·34	2·16
85·5	441·62	1·73	89·0	505·76	1·94	92·5	577·50	2·16
85·6	443·35	1·74	89·1	507·70	1·95	92·6	579·67	2·17
85·7	445·09	1·75	89·2	509·65	1·95	92·7	581·84	2·17
85·8	446·84	1·75	89·3	511·60	1·96	92·8	584·02	2·18
85·9	448·59	1·75	89·4	513·56	1·97	92·9	586·20	2·19
86·0	450·34	1·76	89·5	515·53	1·97	93·0	588·41	2·20
86·1	452·10	1·77	89·6	517·50	1·98	93·1	590·61	2·21
86·2	453·87	1·77	89·7	519·48	1·98	93·2	592·82	2·22
86·3	455·64	1·78	89·8	521·46	1·99	93·3	595·04	2·22
86·4	457·42	1·79	89·9	523·45	2·00	93·4	597·26	2·23
86·5	459·21	1·79	90·0	525·45	2·00	93·5	599·49	2·23
86·6	461·00	1·80	90·1	527·45	2·01	93·6	601·72	2·25
86·7	462·80	1·80	90·2	529·46	2·02	93·7	603·97	2·25
86·8	464·60	1·81	90·3	531·48	2·02	93·8	606·22	2·26
86·9	466·41	1·81	90·4	533·50	2·03	93·9	608·48	2·26
87·0	468·22	1·82	90·5	535·53	2·04	94·0	610·74	2·27
87·1	470·04	1·83	90·6	537·57	2·04	94·1	613·01	2·28
87·2	471·87	1·83	90·7	539·61	2·05	94·2	615·29	2·29
87·3	473·70	1·84	90·8	541·66	2·06	94·3	617·58	2·29
87·4	475·54	1·84	90·9	543·72	2·06	94·4	619·87	2·29
87·5	477·38	1·85	91·0	545·78	2·07	94·5	622·17	2·30
87·6	479·23	1·85	91·1	547·85	2·07	94·6	624·48	2·30
87·7	481·08	1·86	91·2	549·92	2·07	94·7	626·79	2·30
87·8	482·94	1·87	91·3	552·00	2·08	94·8	629·11	2·33
87·9	484·81	1·88	91·4	554·09	2·09	94·9	631·44	2·33
88·0	486·69	1·88	91·5	556·19	2·10	95·0	633·78	2·34
88·1	488·57	1·88	91·6	558·29	2·10	95·1	636·12	2·35
88·2	490·45	1·88	91·7	560·39	2·10	95·2	638·47	2·36
88·3	492·34	1·89	91·8	562·51	2·12	95·3	640·83	2·36
88·4	494·24	1·90	91·9	564·63	2·12	95·4	643·19	2·38
88·5	496·15		92·0	566·76		95·5	645·57	

TABLE III.—CONTINUED.

Temperatures.	Tension	Differences for 0·1°.	Temperatures	Tension.	Differences for 0·1°.	Temperatures	Tension.	Differences for 0·1°.
°	mm.	mm	°	mm.	mm.	°	mm.	mm
95·5	645·58	2·38	97·4	692·04	2·52	99·3	741·16	2·66
95·6	647·95	2·39	97·5	694·56	2·52	99·4	743·83	2·67
95·7	650·34	2·39	97·6	697·08	2·53	99·5	746·50	2·67
95·8	652·73	2·40	97·7	699·61	2·54	99·6	749·18	2·68
95·9	655·13	2·41	97·8	702·15	2·55	99·7	751·87	2·69
96·0	657·54	2·41	97·9	704·70	2·56	99·8	754·57	2·70
96·1	659·95	2·42	98·0	707·26	2·56	99·9	757·28	2·71
96·2	662·37	2·43	98·1	709·82	2·57	100·0	760·00	2·72
96·3	664·80	2·44	98·2	712·39	2·58	100·1	762·73	2·73
96·4	667·24	2·45	98·3	714·97	2·59	100·2	765·46	2·74
96·5	669·69	2·46	98·4	717·56	2·59	100·3	768·20	2·75
96·6	672·14	2·46	98·5	720·15	2·60	100·4	771·95	2·76
96·7	674·60	2·47	98·6	722·75	2·60	100·5	773·71	2·77
96·8	677·07	2·48	98·7	725·35	2·60	100·6	776·48	2·78
96·9	679·55	2·48	98·8	727·96	2·61	100·7	779·26	2·78
97·0	682·03	2·49	98·9	730·58	2·62	100·8	782·04	2·79
97·1	684·52	2·50	99·0	733·21	2·63	100·9	784·83	2·80
97·2	687·02	2·51	99·1	735·85	2·64	101·0	787·63	
97·3	689·53	2·51	99·2	738·50	2·65			
97·4	692·04		99·3	741·16				

TO BE CONTINUED.

Description of the Process of MM. Rivot *and* Phillips, *for Smelting Copper Ores.*

From a paper read before the Society for the Encouragement of Arts and Manufactures, Paris.

In a visit to England in 1845, one of us became acquainted with the experiments made in an English copper works, to extract the metallic copper by means of the action of voltaic electricity, from previously roasted sulphur ores of copper. The information we obtained was the same as was laid before the Society, as descriptive of the process employed by M. Napier.

The sulphur ores were first well roasted, then smelted in a reverberatory furnace, and the copper brought to a metallic state by passing through the fused metallic silicate a very powerful voltaic current; the graphite hearth of the furnace, and a plate of cast iron kept at the upper part of the melted mass, forming the remaining part of the voltaic current.

Starting from these given points, we first tried to reduce by a voltaic current, not the silicate of copper, but the pure sulphuret of copper.

After several ineffectual attempts, we succeeded in passing, during more than two hours, a constant current through a crucible containing sulphuret of copper at a red heat.

In a common Hessian crucible, we placed two small pieces of compact coke, kept at a little distance by well compressed luting; and in these we

plunged two platinum wires communicating with the two poles of the battery. The platinum wires were preserved from the action of the sulphur y the pieces of coke and the luting. We found in these direct experiaents, that coke is a good conductor at a red heat, and that the luting conducts but a very little at that temperature.

Tubes, fixed in two notches of the crucible, had for their object the prevention of contact between the charcoal and the platinum wires, a point of essential importance on two accounts:—First, the burning charcoal would have established a communication between the two poles of the battery outside the crucible, and consequently, a large portion, if not the whole, of the current, would have been deviated, and not have traversed the fused mass. Secondly, the alkaline ashes of the wood charcoal would have rapidly attacked the platinum wires, and the current thus have been interrupted. The copper wires closing the circuit communicated with a galvanometer, the needle of which indicated by its deviation the energy of the current. We employed constant batteries with copper and zinc elements, and solutions of sulphate of copper and common salt, of six to twenty-four couples, and sometimes only one Bunsen battery of thirty elements. We always simultaneously made two comparative experiments, by placing in the furnace two crucibles exactly similar, the one traversed, and the other not traversed, by the current.

We found, after several experiments, that the sulphuret of copper not decomposed by the coke, is but very slightly decomposed by a constant current of twenty-four couples of the voltaic battery, producing a deviation of the needle of the galvanometer of 35° to 40°.

By employing a Bunsen battery of thirty elements, producing a deviation of the needle of the galvanometer of 45° to 50°, we have reduced a notable quantity of copper in a state of fusion; but the largest proportion of the sulphuret remained undecomposed.

These results convinced us that the action of the battery is feeble as regards sulphuret of copper, and that the very powerful voltaic current requisite for effecting the decomposition, as well as the difficulty of conveniently disposing the apparatus, would prevent the employment of this process for the treatment of sulphuret of copper, and *a portion* for that of pyritic copper, which is the most common ore of copper.

Experiments analogous to the preceding, in the which we replaced the two poles of coke by rods of iron, have indicated to us that the action of the battery renders more rapid, but not complete, the reduction of sulphuret of copper by the iron. It always forms a mass, rich in copper. The action of the battery, aided by that of the iron, separates from the sulphuret of copper but a very small proportion of copper.

In analogous experiments made on galena, (sulphuret of lead,) this mineral presented the same characters as the sulphuret of copper. We also found always a great loss in the crucible traversed by the voltaic current, due to the volatilization of the metal. These experiments clearly demonstrated to us that the action of the battery, aided even by that of iron, could not serve as a process for the direct treatment of the sulphurous ores of lead or of copper.

We then repeated the experiments of M. Napier, and endeavored to reduce the fused silicate of copper and iron, by a current brought by two

poles, the one of iron, the other of plumbago, in immediate contact with the fused mass. But we very soon convinced ourselves, that of the three agents employed for the reduction of the oxide of copper, (the plumbago, the iron, and the current,) the first two, especially the iron, were quite sufficient; and numerous experiments proved to us, that by the action of iron alone, a silicate of copper, containing, besides oxides of copper, other bases, such as soda, lime, oxide of iron, &c., gave up, in less than one hour's action of the fire, the whole of its copper united in a button of complete purity.

It is thus that we have been led to search in the action of iron, the principle of the reduction of oxide of copper. We first made several experiments in crucibles, in order to determine the circumstances most favorable to the action of iron. The following are the principal results which we obtained. In our crucible were arranged two or more iron rods, dipping almost to the bottom, and kept at the upper part by a bed of luting. The material employed was either roasted pyritous copper, or a mixture of oxide of copper, oxide of iron, and sand; to these we added as fluxes, soda, or lime, or even chalk only. By employing soda as the flux, the reduction of the oxide of copper was complete in a very short time. At a quarter of an hour's fusion, the copper obtained was chemically pure. With chalk, the complete reduction required one hour's fusion. The copper produced contained much iron, (often 15 per cent.,) when the iron rods dipped down to the bottom of the crucible; and, on the contrary, was always very pure when the rods reached but a little way above the bottom. The time necessary for the complete reduction of the oxide of copper, was more or less great in proportion to the number of iron rods employed.

Satisfied with these results, we constructed a reverberatory furnace, capable of containing about 250 kilogrammes (5 cwt.) of fused metallic silicates, and presenting no other peculiarity of construction than having six grooves, or vertical hollowed out places, in the wall opposite to the door of the furnace. Their use was to maintain in the fused mass six bars of iron of 6 to 8 centimetres (2¼ to 3¼ inches) wide, and 70 centimetres (28 inches) long. These bars thus acted on a large portion of the melted mass, were not in contact with the copper, were readily put in and removed, and we were able to stir the melted mass between the bars, in such a way as to render it homogeneous, and renew the parts in contact with the iron. We have treated in this furnace, more than three tons of the pyritic ores of Cornwall, Germany, and Spain, all previously carefully roasted. This complete roasting is easy enough when the ore is ground with fine sand; it is done with ordinary precaution, but should be finished with a brisk heat. In the first experiment, we commenced by fusing the roasted ore with lime and poor slag; and when the fusion was complete, we applied six bars of iron, which were allowed to remain during four hours. After this time, we removed the bars and ran out the metal. In operating thus, we always found the consumption of iron to be much greater than theory pointed out as sufficient for the reduction of the oxide of copper. The slag retained from 2 to 3 per cent. of copper. We attempted to smelt this slag by itself, and acted upon it with bars of iron for four hours; the result was that we obtained new slag, equally rich in copper with the former; and this, notwithstanding that the bars lost several kilogrammes of weight.

This oxidation of the bars of iron could not be attributed to the air of the furnace which had not served for combustion, since the bars were constantly and entirely plunged into the fused material, but was evidently due to the peroxide of iron contained in the metallic silicate, and which would be brought by the iron to the state of protoxide before the oxide of copper could be completely reduced by the iron. We then endeavored to reduce the consumption of iron, and recover the copper lost in the slag, by adding to the action of the iron that of charcoal or coal. The carbonaceous material might be employed in two ways. First, mixed with the wasted ore; secondly, added after complete fusion, to the compound formed of the fused silicates. In operating in this last manner, we were soon convinced that the charcoal acted but slowly and feebly in the fused silicates, because it floated on the surface of the mass, and could not be kept within it.—Nevertheless, its action is of some account; for when we threw on the melted mass in the furnace a certain quantity of poor coal, we always observed a rapid augmentation of its fluidity, explained only by the reduction to the state of protoxide of iron, of a considerable quantity of the peroxide. The consumption of iron being still very great, we next proceeded to examine the action of the carbonaceous matter, when mixed with the roasted ores before charging the furnace. After several trials, we have adopted as the most convenient proportion of charcoal dust, or small poor coal, that which is required to produce one-half carbonic acid, and one-half carbonic oxide, in combining with the oxygen of the oxide of copper, and that combined with the protoxide of iron in the roasted ore. This proportion gave us, without employing the action of iron, a slag containing $2\frac{1}{2}$ per cent. of copper. We have proved by several trials (1.) that this proportion of charcoal need not be rigorously adhered to; and that it may be either increased or diminished to some extent, without the slag being either poorer or richer in copper, or the quality of the copper altered.—(2.) That in increasing much the proportion of charcoal mixed with the ore, and in raising the temperature of the furnace to a bright white heat, we could always bring the last slag (without the action of iron) to such a point, that it should not contain more than $\frac{7}{1000}$ of copper: but then the copper contained 8 to 10 per cent. of iron. By operating at a lower temperature to that strictly necessary for fusion, we obtained a slag rich enough in copper, and still containing 5 to 6 per cent of iron. (3.) That the action of the bars of iron on the fused silicate, containing 2 to 3 per cent. of copper, is powerful and rapid; and that three hours are sufficient to bring the slag to such a state that it shall contain only $\frac{4}{1000}$ to $\frac{6}{1000}$ of copper, the copper obtained being at the same time free from iron. The following is the mode of operation we were definitely led to adopt:—We charge the heated furnace with a mixture of roasted ore, (3 to $3\frac{1}{2}$ cwt.,) and lime or sand, and the slag of a preceding operation, in quantity convenient for determining the fusion of the material, and charcoal or small coal in the proportion previously indicated. In reckoning only as bases in the charges, the protoxide of iron and the lime, we endeavor to produce a bisilicate, containing 12 to 15 per cent. of lime. Experience has pointed out that a bisilicate of protoxide of iron, one base only, melts very quickly and acquires a great fluidity, but readily gives a copper containing much iron.

After charging the furnace, we throw on the surface of the mass one or

two shovelsful of small coal, for the purpose of preserving the material from oxidation by the flames of the furnace. We stir the mass from time to time, in order to enable it to heat more uniformly, and melt quicker. We sometimes succeed in melting completely in four hours. As soon as the mass commences to agglomerate, the parts which attach themselves to the rakes contain a certain quantity of copper scales; when the fusion is complete, the rods plunged into the melted mass indicate the re-union of the copper at the lowest point of the hearth of the furnace near the discharge hole.

We have always examined the slag swimming on the copper at this moment of the operation, after having carefully stirred the mass, so as to produce slag of a homogeneous quality, and found it to contain 2 to 3 per cent. of copper. When the whole is well melted, we place six bars of iron, weighing altogether from 36 to 45 kilogrammes, (84 to 105 lbs.,) fixing their ends in the grooves in the side of the furnace opposite to the door, taking care to plunge them entirely into the melted mass. We then again throw on the surface of the slag a small quantity of coal, to prevent the peroxidation of the protoxide of iron of the slag by the flames; then, from half-hour to half-hour, we stir with a two-pronged rake (very convenient to clean) the surface of the iron bars immersed in the slag. We also employ, as a powerful means of producing the mixture, a wooden pole, which, plunged into the slag, gives a considerable disengagement of gas, and produces a strong frothing up. The appearance of the slag furnishes but little indication of the progress of the reduction of the metal; we have, however, proved that trials made with a cold rake, plunged for a moment into the fused mass, always presents, on contact with the iron, a reddish metallic tint, strongly marked where the slag was rather rich; a tint which, on the contrary, was scarcely discernible when the slag contained not more than $\frac{4}{1000}$ to $\frac{5}{1000}$ of copper.

We have always found that three to four hours are sufficient to remove the copper from the slag up to $\frac{4}{1000}$ to $\frac{6}{1000}$. After this interval of time, we draw out the bars and run off the metal. The duration of one entire operation is thus about eight hours, and three operations may be readily conducted in one day. The loss in weight of the iron bars varies in our experiments to from 1 to 6 kilogrammes, ($2\frac{1}{4}$ to 13 lbs.,) for quantities of copper of 12 to 42 kilogrammes, (27 to 94 lbs.,) obtained from ores of various qualities. This loss is independent of the richness of the ore, and the consumption of the iron is proportionably less for the rich than the poor ores. For the pyritic ores of Spain, containing 21 per cent. of copper, we have consumed 11 parts of iron for 100 of copper obtained. The English ores which we have melted contained 7 per cent. of copper, 4 to 6 per cent. of arsenic, a small portion of antimony, and some traces of tin; from these we have obtained an impure black copper, containing 3 to 5 per cent. of arsenic, 2 to 3 per cent. of tin, and only a few thousandths of sulphur and iron. This result has not surprised us; the arsenic can only be completely driven away by a great number of successive operations, and alternations of roasting and reduction. Thus, we do not propose the application of our process for the treatment of ores containing much arsenic or antimony—as, for example, the grey copper ores. With the pyritic

ores not containing arsenic, we have always obtained a very pure black copper, containing only from $\frac{3}{1000}$ to $\frac{5}{1000}$ of sulphur and iron.

The roasting has a certain influence on the quality of the copper, and on the consumption of iron. With well roasted ores we never had a deposit underneath the copper, which was the case with ores imperfectly roasted. The copper contained not the least iron, and less than $\frac{8}{1000}$ of sulphur. The consumption of iron was much less with well roasted ores, and the final slag less rich in copper. The temperature which we have adopted as the most convenient, is that which is strictly necessary for the fusion of the copper and the slag. Too high a temperature renders the action of the iron on the silicate of copper more rapid and energetic; but the coal reduces more easily a part of the oxide of iron combined with the silica. In operating in the same manner, on the same mineral, at a well-regulated temperature, and at a bright red heat, maintained from the commencement of the operation, we have obtained, in the former case, a copper of sufficient purity; in the latter case, a copper contaminated with 3 per cent. of iron.

The consumption of coal employed in our furnace, will not give a great indication as to the quantity which would be required in a large reverberatory furnace kept in constant operation. We can, however, give a calculation of sufficient approximation from the consumption of the large copper furnaces in Wales.

The ores to which our process may be applied with the greatest advantage, are the oxides or pyritic ores, with a gangue of pyrites or oxide of iron; they render, by our mode of treatment, copper of excellent quality. These ores, as at present treated, yield a black copper containing much iron. Our process is also readily applicable to all the ores of copper which do not contain too much arsenic or antimony. The process which we have described offers several marked advantages over the methods ordinarily employed. It is rapid and economical, since, by one single fusion, we obtain a slag sufficiently poor to be rejected, and all the copper in a state of sufficient purity to be sold after one smelting, or at the most a short refining. It requires no difficult manipulation, and the workmen can readily understand the way of conducting the operations. The complete roasting of the ore is not a new operation in metallurgy; it is easily accomplished when the ore is ground with sand of sufficient fineness; it requires tact and attention on the part of the workmen, and should be finished by a good stroke of the fire, in order to decompose the sulphates formed at a lower temperature. We have previously pointed out that the principal inconvenience of an incomplete roasting is, in the smelting, a greater consumption of iron, and a less complete removal of the copper from the slag in a given time. A good roasting furnace should contain about $1\frac{1}{2}$ tons of ground ore: the operation should be continued from 15 to 24 hours. For the smelting, the furnaces should be similar to the large reverberatory furnaces of Wales, and contain for a charge 24 cwt. of ore. There should be three smelting furnaces for four roasting furnaces, supposing that three operations may be conducted in each smelting furnace daily. The refining of copper of the first smelting may be done in a furnace containing four tons; an operation which does not require more than 12 hours. To give an idea of the principal *matériel* necessary for the production of a certain quantity of copper, we will suppose that we have to treat a pyritic ore of

copper with a gangue of pyrites or quartz, containing at the most 15 per cent. of copper. To produce per annum 100 tons of copper, there will be required two pair of stamping mills, twelve roasting furnaces, eight smelting furnaces, and one copper refining furnace.

It will also be very advantageous to annex to the copper-works an iron works, which would produce at a low price the iron necessary for the tools and implements employed, the bars, &c., and to use up the old bars which will no longer serve in the smelting furnaces. We have also applied the action of iron on the metallic silicates in fusion to the treatment of sulphate of lead, but less successfully than in the case of copper ores. These trials have been made on a large scale in a reverberatory furnace capable of containing 24 cwt. of materials.

To the dry sulphate of lead, we added sand, a little chalk, the slag of a preceding operation, and about three per cent. of charcoal. A larger proportion of charcoal always gave a little sulphuret of lead with the metallic lead. We charge the furnace, and heat it so as to effect an entire fusion for the space of five hours. We then throw into the fluid mass, at three or four times, iron turnings, which replace to great advantage the bars of iron. The proportion of cast iron turnings necessary is about one-eighth of the weight of the dry sulphate of lead. We stir the mass very frequently, and after four or five hours' action of the iron, run off the metal. We have obtained, in this manner, 45 to 48 parts of lead from 100 of sulphate of lead. The loss, therefore, of metal was considerable, which was due in great part to the volatilization of the lead, the fumes of which were evident at the top of the chimney; this volatilization principally took place during the stirring and the charging. We notice this application of our process to the reduction of sulphate of lead, because that it proves that iron acts very rapidly on the silicate of lead, and that this action might be employed under certain circumstances.

To complete the description of the process for the metallurgical treatment which we propose, we now proceed to give an estimate of the probable cost of the treatment of copper ores. We base this estimate on the duration of the operations in the reverberatory furnaces in which we have treated the ores of copper and the sulphate of lead; on the consumption of coal in the large smelting furnaces in Wales; and on the consumption indicated from our own experiments.

To compare our process with that adopted in the greater number of copper-works in England, we have adopted the figures given by MM. Dufrenoy, Elie de Beaumont, Costa, and Perdonnet, in their "*Voyage Métallurgique en Angleterre.*" We will reckon the cost for one ton of pyritic ore, having a gangue of quartz and iron pyrites. For the refining, we calculate the expense for one ton of copper.

RIVOT AND PHILLIPS' PROCESS.

First Operation.—Grinding of the ore.

For one ton, - - 1*fr.* 50*c.* = 1*s.* 3*d.*

Second Operation.—Roasting of the ore in furnaces containing 36 cwt. Duration of roasting process, 18 hours. (We may remark that for the roasting, the lost heat from the smelting furnaces may be very well employed, as is done in some English works.)

Labor, 1½ day at 2 francs, - -	3 *fr.*
Coal, 6 cwt. at 1 *fr.* per 2 cwt. -	3
Total,	6 *fr.* = 5*s.*

Third Operation.—Smelting of the roasted ore. Furnaces containing 1½ ton of ore (weight of crude ore). Duration of operation, eight hours. Consumption of coal per hour, on an average, 120 kilo.=2 cwt. 1 qr. 16 lbs. The iron is put at 25 *fr.* the 100 kilo.=20*s.* the 2 cwt.

Labor, 0·87 day at 2 francs,	1*fr.*	74*c.*
Coal, 640 kilogrammes at 1 franc,	6	40
Iron, &c.,	9	00
Special expenses,	17	14 = 13*s.* 8*d.*

This operation gives all the copper contained in the ore in the state of black copper, containing but a very little iron and sulphur.

The special expenses of the treatment of one ton of copper ore of ordinary quality, 6 to 30 per cent., according to our process,

Grinding, - -	1*fr.*	50*c.*
Roasting, - -	6	00
Smelting, - -	17	14
Total,	24	64 = 19*s.* 9*d.*

Fourth Operation.—Refining of the black copper obtained by smelting. In a furnace containing 4 tons of copper. Duration of the operation, 12 hours. Mean consumption of coal per hour, 2 cwt.

For one ton of copper:—

Labor, 1 half-day at 3 francs,	1*fr.*	50*c.*	1*s.*	3*d.*
Coal, 1½ cwt. at 1 franc,	1	50	1	3
Total,	3	0	2	6

For an ore rendering 8 to 10 per cent. of copper, the refining will add about 30 per cent. to the expenses.

In adding to these expenses 3 francs (2*s.* 6*d.*) for repairs of implements, &c., we arrive at a sum of 27 *fr.* 94*c.* for the expenses of the treatment of one ton of ore, comprising the refining—say in round numbers, 28 *fr.* (22*s.* 6*d.*) For a return of 8 to 10 per cent., the special expenses for one ton of refined copper will be 350 francs (14*l.*); for a return of 25 per cent., 112 francs (4*l.* 10*s.*).

WELSH PROCESS.

The special expense of the treatment of one ton of ore, containing or rendering 8 per cent. of copper, is as follows:—

Coal, 1600 kilogrammes at 1 franc,	16 *fr.*
Labor, &c. &c.	26
Total,	42 *fr.* = 33*s.* 2*d.*

Difference in favor of our process, 14 francs (11*s.* 8*d.*).

For one ton of copper, and for the ores ordinarily treated in Wales, the difference in the special expenses of the treatment is 175 francs (7*l.*).

The Society for the Encouragement of the Arts and Manufactures, and the Academy of Sciences, have both reported favorably on the process of MM. Rivot and Phillips. Civ. Eng. & Archi. Journ., Nov. 1848.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On Boring the Earth for Minerals, Artesian Wells, and other purposes.

BY MR. JOHN THOMSON.

To the Committee on Publications.

GENTLEMEN:—The geometrical progression of practical science during the past half century must be apparent to every thinking person; the advancement of any one science generally affecting some other in a greater or less degree, and thus producing a universal movement.

I beg leave, through the medium of the Journal, to point out an art which has received no material improvement in this country, although its claims are strong and of paramount importance. I allude to boring the earth for minerals, artesian wells, or other purposes.

The enormous labor, delay, and other vexations attendant on rod boring, are well known, and do not require examples to enforce conviction; yet strange to say, that same old awkward system even yet holds good its footing. The Chinese method, which is much more simple and effective, is being adopted in Europe, and might be also here. It consists of an armed weight, (say one, two, or three hundred pounds, as the case may be,) of a particular form, attached to a peculiar rope, to withstand the friction on the sides of the bore hole, whilst at work, and being suspended from above by a spring, on which two men are seated. The weight is made to bob up and down by their exertions, striking the bottom at each depression of the spring, the boring being advanced with considerable rapidity. The clearing of the detached matter by this method, is also very much facilitated as compared with the rod boring system.

These are the only two methods at present known, for boring the earth to any great depth, and they do not admit of much improvement.

But I contend that other methods may be found to supersede these, and would suggest the powers of the electro magnet, an agent whose limit of energy is yet unknown. The small space through which it can exert its immense powers, renders it peculiarly adapted to boring purposes, either perpendicularly, horizontally, or at any other angle; being a particular advantage gained over any of the other methods, and quite applicable to direct mining.

Suppose, for instance, a short boring instrument to have a common magnet inserted into it, with the poles uppermost. Again suppose a mate to this magnet, of the electro description, firmly inserted into a heavy weight. Next let us imagine these two magnets to be set upon each other, face to face, the under one with its boring tool, and the upper with the weight. It will be evident that, by connecting an electro-magnetic battery to the upper magnet, and reversing the polarity as usual with that machine, a power will be exerted between these two magnets, tending, at each alternate reversal of polarity, to separate them and produce a shock.

Such is the principle upon which I propose my mining machine. If the weight which bears upon the magnets be 3 cwt., and the magnets to have a sustaining power of 2 cwt., action and re-action being equal, I ask what would be the impinging power exerted by the borer upon the opposing rock, when in operation?—for certainly this is a projectile, and must be calculated accordingly.

Suppose the battery to reverse its polarity 10 times a second, and the magnets to separate only the thousandth part of an inch at each pulsation, (the clearing of the hole by the recently invented method of pumping water down, being approved of,) the progress will be found to be three feet per hour.

I do not calculate on receiving any benefit whatever from the attractive principle of the magnets; but I receive in full the whole amount of their repulsive energy. The weight which loads the magnets being superior to the sustaining power, the stroke can never have an ascending tendency; the boring machinery must sink while the battery on the surface is in operation, and the weight which loads the magnets, follows the descending borer by its own gravity. In boring from the surface, the battery remains above, and the wires connect with the magnet, however deep the workings may be, the points being shielded from danger of soiling by a simple sheath. As the borer will remain constantly at the bottom of the hole, there will be no power lost, as in the other methods, by the displacement of the loose matter at every stroke of the cutter.

Not being a practical miner, although I have investigated the theory somewhat, I would leave the form of the cutting tools to those better versed with that subject, remarking that, in cutting hard rock, a single chisel would get wedged in; but by using two common magnets, with a chisel to each,—a positive end of the one magnet, and a negative of the other, being presented to each end of the one electro-magnet,—they would work alternately, and at every reversal of polarity; producing a double effect, and freeing each other's chisel at every stroke.

This electro-magnetic method of boring admits of being carried to any depth, as the magnets descending with the chisels, carry with them the same amount of energy as when at the surface, and as the sustaining power of the electro-magnet may be increased many fold above the example I have instanced, it leaves no doubt in my mind, but that a powerful agent is here presented to the mining interest of the country.

Regarding lateral borings, it is only necessary to use pressure on the magnets, instead of the heavy weight with which I have illustrated my description, and the mode in which it will be applied, will depend on the nature of the work to be executed. From the friable nature of coal, I should say that this machine might be introduced into the mining of that mineral with certain success, as an auxiliary to the men, in the manner of a pioneer, in cutting always in advance of the workers, leaving them merely the work of pulling down the walls which it has bored into and undermined.

I have been as concise as possible, but I hope sufficiently clear to convey an idea of the principle. I have never attempted it in operation, but recommend and leave it to any party who may feel interested. I believe the idea to be new and good, and take this method to throw it to the world, for others to improve.

Experiments on the Cohesion of Mortar.

The following record of experiments on the *cohesion* of mortar, has been forwarded to us by Mr. B. Baylis, of Chester. The area of the bedjoint was $4\frac{1}{2}$ inches by $4\frac{1}{2}$ inches.

Materials.	Proportions.	Breaking Weight in lbs.
Common lime and sand, - -	$2\frac{1}{2}$ to 1	Broke at 160 lbs.
Ditto ditto, - - -	2 " 1	Do. by accident.
Ditto ditto, - -	$1\frac{1}{2}$ " 1	Do. at 100 lbs.
Ditto ditto, - - -	1 " 1	Do. by accident.
Ground lime and sand, - -	$2\frac{1}{2}$ " 1	Do. at 95 lbs.
Ditto ditto, - - -	2 " 1	Do. at 140 lbs.
Ditto ditto, - -	$1\frac{1}{2}$ " 1	Do. at 235 lbs.
Ditto ditto, - - -	1 " 1	Do. at 215 lbs.
Common lime and fine hammer scale, -	$2\frac{1}{2}$ " 1	Do. at 90 lbs.
Ditto ditto, - - -	2 " 1	Do. at 100 lbs.
Ditto ditto, - -	$1\frac{1}{2}$ " 1	Do. at 90 lbs.
Ditto ditto, - - -	1 " 1	Do. at 65 lbs.
Ground lime and coarse hammer scale, -	$2\frac{1}{2}$ " 1	Do. at 270 lbs.
Ditto ditto, - - -	2 " 1	Do. at 280 lbs.
Ditto ditto, - -	$1\frac{1}{2}$ " 1	Do. at 275 lbs.
Ditto ditto, - - -	1 " 1	Do. at 260 lbs.
Common lime and coarse hammer scale,	$2\frac{1}{2}$ " 1	Do. at 140 lbs.
Ditto ditto, - - -	2 " 1	Do. at 80 lbs.
Ditto ditto, - -	$1\frac{1}{2}$ " 1	Do. by accident.
Ditto ditto, - - -	1 " 1	Do. at 130 lbs.
Ground lime and fine hammer scale, -	$2\frac{1}{2}$ " 1	Do. at 265 lbs.
Ditto ditto, - - -	2 " 1	Do. at 230 lbs.
Ditto ditto, - -	$1\frac{1}{2}$ " 1	Do. at 265 lbs.
Ditto ditto, - - -	1 " 1	Do. at 265 lbs.

Lond. Builder, Oct. 1848.

Method of Welding Iron, Steel, and Sheet Iron.

In an earthen vessel melt borax, and add to it $\frac{1}{10}$ of sal ammoniac. When these ingredients are properly fused and mixed, pour them out upon an iron plate, and let them cool. There is thus obtained a glassy matter, to which is to be added an equal quantity of quick lime. The iron or steel which are to be soldered are first heated to redness; then this compound, first reduced to powder, is laid upon them—the composition melts and runs like sealing wax; the pieces are then replaced in the fire, taking care to heat them at a temperature far below that usually employed in welding; they are then withdrawn and hammered, and the surfaces will be found to be thus perfectly united. The author asserts that this process, which may be applied to welding sheet iron tubes, never fails.—*Rec. de la Soc. Polytech.*

Ibid. Sept. 1848.

The Copying Telegraph.

Experimental trials have been recently made of the copying electric telegraph invented by Mr. Bakewell, by means of which it is intended to make *fac simile* copies of written communications, so that correspondents in distant towns may recognize each other's handwriting. The experiments were

made between the Electric Telegraph Company's branch station, in Seymour street, and Slough, for the purpose of ascertaining whether the same amount of electric power that works the needle telegraph would be sufficient for the copying process. We understand that the result was most satisfactory; and that legible copies of messages written in London, were received at Slough with double the rapidity that could be attained by the needle telegraph. The instruments were much smaller than those that will be employed in regular work; and we hear that Mr. Bakewell expects to be able to transmit as many as 400 letters of the alphabet per minute, with a single wire. Independently of the great rapidity of which this means of communication is susceptible, the copying telegraph would give greater certainty to such information, not only because errors of transmission would be avoided, but the agent, on recognizing the handwriting of his correspondent, would act with more confidence than he can do on receiving instructions of the authenticity of which there is no proof.—*Literary Gazette.*

Lond. Athen. Oct. 1848.

Experiments on Galvanized Wire and Hemp Ropes.

An experiment was lately tried in Woolwich Dockyard, to ascertain the comparative strength of wire and hemp ropes. A wire rope, 3 inches round, and a hemp rope of three strands, hawser laid, common make, 7 inches round, were spliced together, and placed in the testing machine, and on the hydraulic power being applied, the hemp rope broke in the middle, on the strain reaching $11\frac{3}{4}$ tons, the wire rope remaining apparently as strong as when the experiment commenced. A wire rope, $3\frac{1}{2}$ inches round, was then spliced with an 8-inch hemp shroud rope, and on the power being applied, the hemp rope broke in the middle, with a strain of $10\frac{1}{2}$ tons, the wire rope continuing apparently uninjured.

Civ. Eng. & Archi. Journ., Nov. 1848.

To Transfer Engravings to White Paper.

Place the engraving for a few seconds over iodine vapor. Dip a slip of white paper in a weak solution of starch, and when dry, in a weak solution of oil of vitriol. When dry, lay the slip upon the engraving, and place them for a few minutes under a press. The engraving will thus be re-produced in all its delicacy and finish. The iodine has the property of fixing on the black parts or ink of the engraving, and not on the white. This important discovery is yet in its infancy. Lond. Builder, Mar. 1848.

Analysis of Wrought Iron produced by Cementation from Cast Iron.

BY PROF. MILLER.

It is to be noticed that considerable change in the specific gravity occurred in the iron after cementation: it was forged, and then found to have increased in density; the brittle iron had a specific gravity of 7·684, the malleable, 7·718. The results of analysis were briefly these:—the quantity both of carbon and silicon are materially diminished by the cementation, though still the proportion of both is materially greater than in good bar